THE DEVELOPMENT OF AN INSTRUMENT TO MEASURE HANDBALL ABILITY OF BEGINNING LEVEL PLAYERS IN A PHYSICAL EDUCATION CLASS

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CHAPTER I

INTRODUCTION

Many significant changes have occured in Physical Education during the past one hundred years. The two most important changes for teachers in the profession are the philosophy of educating the student and the method of evaluation.

Since the beginning of the twentieth century, a new philosophy of physical education has been developed by the efforts of Thomas Wood and Clark Hetherington. These leaders had recognized the importance of the new psychological thought that the "mind" and "body" cannot be considered separately in the education of an individual. The pioneer leadership of Wood and Hetherington was abetted and augmented in the 1920's by two younger proponents, Dr. Jesse Fiering Williams and Jay B. Nash. In William's Treatise of 1930, he coined the phrase, "An education of the physical and an education through the physical."[1] The two terms

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[1]Jesse Feiring Williams, "Education Through the Physical," Journal of Higher Education, Vol 1 (May, 1930), pp. 279-282.

have been adopted to explain the difference between physical education philosophies before and after the turn of the century.

Education of the physical was the traditional philosophy of physical education before the 1900's. During the last half of the nineteenth century, formal instruction was virtually dominated by the German system. These programs tended to ignore over all education of the student in their preoccupation with exercises designed to develop the physical body by improving posture and coordination. Indictment was brought against the traditional program on three counts:

1. It sought postural and corrective results that are not satisfactorly obtained in class exercises by formal movements involving consciousness of muscle and body by the pupil. Except for individual cases needing remedial gymnastics, these results may be gained as well or better through exercises that are more natural, spontaneous and enjoyable.

2. It concentrated too much upon the body and lacked sufficient regard for the attitude of the mind and the effects upon disposition and personality.

3. It developed various forms of ability that are not closely enough related to activities of human life to justify the time and effort given to them.[2]

The physical education profession has been criticized in many quarters for its early insistence on education of

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[2]Debold B. Van Dalen, Elmer D. Mitchell and Bruce Bennett, A World History of Physical Education, (New Jersey, 1953), p. 428.

the physical. Many people had associated physical education with punishment exercises commonly employed by the military to develop and maintain discipline, muscle building and the uncomfortable feeling of perspiration. Development of the intellectual capacity could not be claimed as a result, because the curriculum was designed mainly for development of the body by gymnastic exercises and not the intellectual stimulation of the mind by having the individual think before moving the body.

The concept of education through the physical considers the individual as an integrated or whole person. "Wholeness or whole man does not mean complete or perfect man, but soundness in which the major elements of personality are related."[3] It is centered on the Gestalt psychology which stated, "The phenomenon we perceive is the whole and not the sum of the parts."[4] More specifically toward physical education it has been stated as follows:

> When mind and body were thought of as two separate entities, physical education was an education of the physical. In similar fashion, mental education made its own exclusive demands. With the understanding of the nature of the human organism in which wholeness of the individual is the outstanding fact, physical education becomes education through

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[3]Delbert Oberteuffer and Celeste Ulrich, Physical Education, (New York, 1962), p. 36.

[4]Louis P. Thorpe and Allen M. Schmuller, Contemporary Theories of Learning, (New York, 1954), p. 205.

> the physical. With this view, physical education has concern for and with emotional responses, personal relationships, group behaviors, mental learnings and intellectual, social, emotional and esthetic outcomes.[5]

The new concept of physical education challenged the traditional thought that development is physical. The experiences which an individual receives are based on the development of the intellectual capacities and personality. In the words of Andras, "Physical Education seeks the development of personality which is defined dynamically as the process of living."[6]

The english system of sports and games was selected by the proponents of the new philosophy for educating the student through the physical. The system made inroads into the curriculum after the turn of the twentieth century and challenged formal gymnastics in the famous "Battle of the Systems."[7] For two decades, the two systems coexisted in physical education programs. The battle ended after the termination of World War I and sports and games emerged as the principal emphasis for future curriculums.

Just as the philosophy of educating the student has changed, so has the method of evaluation. Agnes Wayman has

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[5]Jesse F. Williams, The Principles of Physical Education (Philadelphia and London, 1959), p. 2.

[6]Angyal Andras, Foundations for a Science of Personality, (New York, 1941), p. 374.

[7]Arthur Weston, The Making of American Physical Education, (New York, 1962), p. 53.

stated, "The profession has progressed from the days of facts, figures and the correct angle of toe pointing to a measurement of skill habits, attitudes and appreciation of activities involved in daily living."[8]

The first method of evaluation in physical education was anthropometric testing which was developed by Edward Hitchcock at Amherst College in 1869.[9] He was primarily concerned with the physical-developmental needs of the students as individuals. His eight research items were: age, weight, height, chest girth, arm girth, forearm girth, lung capacity and pull ups. A second type of evaluation which was commensurate with the philosophy of "education through the physical" was introduced by Sargent in 1873.[10] The evaluative technique was called "strength testing". The intent of Sargent was to improve the individual in structure and function. The measurements which were developed by Hitchcock and Sargent have become an integral part of the academic work of the physical education profession in the twentieth century, but they are not the sole means of evaluation.

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[8]Agnes Wayman, A Modern Philosophy of Physical Education, (Philadelphia, 1938), p. 54.

[9]Emmett A. Rice, John L. Hutchison and Mabel Lee, A Brief History of Physical Education, (New York, 1969) p. 217.

[10]C. W. Hackensmith, History of Physical Education, (New York, 1966), p. 365.

The emphasis on measurement changed during the first decade of the twentieth century in order to extend the horizons of physical education. Hetherington outlined four objectives for the "new physical education". The goals were organic development, psychomotor education, character education and intellectual education.[11] The changing philosophy prompted a vast number of tests which were constructed and utilized during this period. According to Van Dalen et, al., testing during this era had two basic functions:

1. To provide accurate data on the status of individual pupils regarding health, abilities and capacities, in order to ascertain individual needs.

2. To measure progress or achievement of pupils in terms of objectives desired in the physical education program. The results could be used both as a basis for grading and for evaluation of teaching efficiency.[12]

Testing was expanded to include cardiovascular research, general motor ability appraisal, attitudinal ratings and measurement of sports skills.

The dominance of strength testing in the 1800's was weakened by the new interest in cardiovascular research. This was primarily due to new findings in medicine and the introduction of the ergograph. In 1905, Crampton devised

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[11] Benjamin H. Massey, "Measurement; Historical Review", An Introduction to Measurement in Physical Education, Vol. 1, ed. Henry Montoye, 1970, p. 45.

[12] Van Dalen, p. 460.

the Blood Ptosis test.[13] In 1910, McCurdy developed standards for heart rate and blood pressure.[14] George Meylon devised tests of cardiovascular effeciency in 1913.[15] After World War I, the Schneider Index of cardiovascular efficiency and the Tuttle pulse-ratio scales were established.[16] Measurement in the area of cardiovascular research received a distinct and permanent boost in 1930 when the Research Quarterly came into being. A good majority of the investigations in physical education are still being conducted in this area.

Tests of general motor ability were introduced in 1904 by Halsey Gulick for the Y.M.C.A. and by George Meylon in 1907 for college grading in physical education classes.[17] These tests were designed to ascertain the "all round athlete". When statistical methods were applied to physical education in the 1920's, Charles McCloy devised achievement

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[13]Ibid, p. 462.

[14]Ibid, p. 462.

[15]Ibid, p. 462.

[16]Ibid, p. 462.

[17]Weston, p. 55.

[18]Charles H. McCloy, "A Statistical and Mathematical Method of Devising Athletic Scoring Tables", American Physical Education Review, XXXVI (January, 1921), pp. 1-12.

scales. David Brace[19] developed a battery of tests for women's basketball and used McCloy's new T-score technique for scoring the results. Three years later, Brace devised his motor ability test of twenty stunts. The battery was modified by Charles McCloy and is still in use.[20] During the same era, Sargent developed his jump test.[21] Motor ability tests during the past three decades have been primarily confined to indexes of physical fitness.

Attempts were also made to assess character outcomes and social values which were proclaimed as objectives of physical education. In 1928, Buskirk[22] sought to evaluate moral qualities and social traits resulting from physical education. In 1930, character ratings were reported by McCloy.[23] Studies of attitudes toward physical education have been multitudinous since the early attempts and they are continuously being introduced at present.

Due to the expanding interests in the sports and games programs inherent in the new physical education curriculum,

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[19]David K. Brace, "Testing Basketball Technique", American Physical Education Review, XXIX (April, 1924) pp. 159-164.

[20]Massey, p. 28.

[21]Van Dalen, p. 463.

[22]Luther Van Buskirk, "Measuring the Results of Physical Education", Journal of Educational Method, VII (February, 1928), pp. 221-229.

[23]Charles H. McCloy, "Character Building Through Physical Education", Research Quarterly, I (October, 1930) pp. 41-61.

there was a need for the measurement of individual skill ability. As a result, sports skills tests were introduced to measure the basic skills used in the playing of a specific sport. The early pioneers in this area were David K. Brace, Thomas Cureton, Ester French and Gladys Scott.[24] Cozens, Cubberly and Neilson developed some of the earliest achievement scales in sports skills.[25] The first test, labeled as a sports skills test battery, was introduced by Brace in 1927.[26] The test battery consisted of six items designed to measure the ability of a basketball player. During the 1930's and 1940's, a plethora of test batteries were introduced to measure abilities in the various games and sports commonly found in the physical education curriculum. Unfortunately, the emphasis turned to physical fitness tests during World War II and thereafter. Sports skills test batteries currently in use are twenty to thirty years old.

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[24]Karl Bookwalter and C. Bookwalter, "Sports Skills", Measurement and Evaluation Materials in Health, Physical Education and Recreation, (Washington, 1950), pp. 16-19.

[25]M. Phillip and A. J. Wendler, "General Motor Skills", Measurement and Evaluation Materials in Health, Physical Eduation and Recreation, (Washington, 1950), p. 14.

[26]John F. Bovard, Frederick W. Cozens and Patricia Hagman, Tests and Measurement in Physcial Education, 3rd. ed., (Philadelphia and London, 1949), p. 37.

On the surface, it would seem that there has been a smooth transition from one teaching philosophy to another and the appropriate measuring devices have been developed to evaluate students as the need required in a particular activity. Unfortunately this is not the case in all instances. John Faulkner and Kathryn Luttgens have many reservations about the tests which are currently available:

> Many of the published tests of sports skills do not mmet adequate criteria of reliability, objectivity or even "face validity" in the sports and for the same sport at different grade levels. Some existing sport skill tests were initially worked out with great care and attention to statistical analysis. Changes in rules, playing skills and coaching techniques have made many tests obsolete. In other sports, there are no adequate test batteries. New or completely revised test batteries are necessary in these instances. Where objective tests seem inappropriate, validated subjective tools, such as the skills standards approach are necessary.[27]

Authorities have been particularly critical of the test batteries which have been developed for the game of handball. Luttgens, McArdle and Faulkner claim that "Several handball test batteries were developed since the thirties, but were selected on the basis of empirical judgement and the data were not statistically analyzed. One test had an

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[27]John A. Faulkner and Kathryn Luttgens, "Introduction to Sports Skills Testing", An Introduction to Measurement in Physical Education, Vol. 3, ed. Henry Montoye, 1970, p. 14.

established validity, but reliability and objectivity were not reported."[28]

Handball is a relatively recent addition to the physical education curriculum at the college and university level. Common after 1960's the game has been excluded at many institutions because facilities were not available and a great deal of space is required in which only a small number of students can participate. In the past decade, there has been a rapid increase in the number of courts in colleges and universitites throughout the country.

It has been stated by Staley[29] that one of the major objectives of the new physical education curriculum is to teach skills in an activity that has good carry-over value and help the participant maintain a high level of fitness. Handball adequately meets this objective. In fact, handball is considered such an excellent means of physical conditioning and recreational activity that large companies, such as the General Dynamics Company in Fort Worth, Texas, built courts for their employees in 1973. The NASA officials have built courts for the astronauts at the space

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[28]Kathryn Luttgens, William D. McArdle and John A. Faulkner, "Individual and Dual Sports Skills Tests", An Introduction to Measurement in Physical Education, Vol. 3, ed. Henry Montoye, 1970, p. 45.

[29]Seward C. Staley, The Curriculum in Sports, (Philadelphia, 1935), p. 4.

centers in Houston and Cape Kennedy. Handball courts have also been constructed on many Armed Service bases in the United States and abroad. Facilities have also been made available during the past ten years at Y.M.C.A's, Jewish Community Centers and athletic clubs throughout the country.

Since the activity is relatively new to the curriculum, it is imperative that an evaluative instrument be developed to determine the ability level of the participants who engage in the sport. A test for beginning players is particularly vital, since most test batteries have been developed for skilled players. The need for a valid instrument in handball is further stimulated by the trend of many colleges who have already begun to offer advanced courses in the activity and other institutions who have adopted proficiency programs. The nationwide study by Oxendine[30] in 1969 revealed that many four year institutions are adopting proficiency programs and team sports are being reduced or eliminated in favor of such dual sports as handball and tennis. Without a means of evaluating attainment of minimal skill requirements, colleges have difficulty in properly classifying students for an advanced course or for release from the activity.

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[30]Joseph B. Oxendine, "Status of Required Physical Education in Colleges and Universities", Journal of Health, Physical Education and Recreation, Vol. 40, No. 1, (January, 1969), pp. 32-39.

At present, there is only a limited amount of literature available on handball. Books and articles deal primarily with an explanation of rules and skills involved in the game, but very little information is available to determine how the ability of a handball player can quickly and validly measured. In this study, the investigator was primarily concerned with obtaining a valid, reliable and objective measure for beginning level players.

Statement of the Problem

The purpose of this investigation was to develop a test battery which will classify a beginning handball player according to ability. More specifically, the intent was to determine if ability can be predicted by the proficiency in one or more of the eight test items in the battery of tests. The eight skill measures selected for the test battery were considered as those which are most closely related to successful performance in the game.

Limitations

The subjects were selected from six physical education classes. All subjects were beginning level players. The criterion was a partial round robin, because the subjects only competed against those subjects in their class and not against every subject in the study.

Delimitations

The measurements collected for this investigation included testing of the dominant and non-dominant hands in terms of power, control and accuracy for the overhand, sidearm and underhand delivery from a stationary position. The subjects were also tested for coordination and their ability to move into a set position for a combination of the three deliveries in a modified game situation.

The subjects consisted of one hundred two college age males from the University of Illinois at Chicago Circle who were in their last week of a basic activity course in handball during the winter Quarter of 1973. Ages ranged from eighteen to twenty-five years old.

The investigation was primarily concerned with the game as it is played in a regulation (20' x 20' x 40') handball court. The test battery was designed specifically for beginning players.

Assumptions

Since motivation has been found to influence skill test performances as revealed by Smithells and Cameron,[31] it was assumed in this investigation that any possible differences in this variable will be cancelled out through a random

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[31]Phillip A. Smithells and Peter E. Cameron, Principles of Evaluation in Physical Education, (New York, 1962), p. 232.

effect between the groups tested. Also, only one subject was tested at a time by each examiner. No observers were present at the time of the test.

Definition of Terms

1. Alternate Hit: Hitting the ball with the dominant and then the non-dominant hand consecutively.
2. Control: The ability of a player to hit the ball into a desired area of the court.
3. Criterion: The results of a partial round robin handball tournament.
4. Delivery: The act of serving the ball, returning the service or any return to the front wall during the test.
5. Dominant Hand: The hand which exerts more power and control when hitting the ball.
6. Kill Shot: A ball delivered to the front wall (no higher than twenty-four inches from the floor). In a game situation, it is described as a ball which rebounds from the front wall or side wall so close to the floor that it cannot be returned by the opponent.
7. Long Game: The ability to continuously return the ball to the fron wall when standing to the rear of the short line.
8. Match: Fifteen minute game of handball with one opponent.

9. Non-Dominant Hand: The hand which exerts the least amount of power and control when hitting the ball.
10. Overhand Return: Any return contacted at full arm extension above the head of a player.
11. Service Line: The closest parallel line to the front wall.
12. Short Game: The ability to continuously return the ball to the front wall while standing in front of the short line.
13. Short Line: The parallel line closest to the back wall.
14. Volley: A continuous succession of returns to the front wall.

CHAPTER II

REVIEW OF THE LITERATURE

After reviewing the literature, it was obvious that many attempts have been made to develop measuring devices to be used as predictors of playing ability in a handball game. These attempts consist of skill test batteries, knowledge tests, subjective ratings in game situations, physical characteristics, strength, classification by modified tournaments, proper application of the mechanical principles of the stroke, linear velocity of the ball, movement, performance and reaction times. Some of the studies have been statistically treated, while others have not. With the exception of one study, none of the research had been conducted in a regulation four wall handball court.

The literature reviewed will be presented chronologically under the following headings: (1) Skill Test Batteries, (2) Subjective Rating Systems, (3) Classification According to Modified Tournaments, (4) Duration and Type of Training, (5) Reaction Time, Performance Time and Handball Velocity and (6) Mechanics of the Best Handball Stroke.

Skill Test Batteries

One of the first skill test batteries was developed by Clevett in 1935.[1] The test was one of several sport skill tests that Clevett used in trying to determine an all-round athletic champion. His handball battery consisted of a service to a marked area in the back court, a back wall return to a target area on the front and determination of speed in returning the ball using full arm, overhand and wrist snap strokes. Points were scored for successful attempts and the speed of the returns was subjectively rated. The results of the study did not indicate that any attempt was made to validate or find the reliability of the individual test items.

In 1937, Edgren and Robinson[2] published a series of individual skill tests for various physical activities. One of the tests was specifically related to handball. Their test battery included a fifteen second speed test volleying a ball against a wall fifteen feet away, an accuracy test in which the ball was hit to a target on the front wall, a

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[1]Melvin A. Clevett, "All-Around Athletic Championship", Journal of Health and Physical Education, Vol. 6, No. 1 (March, 1935), p. 87.

[2]H. D. Edgren and G. T. Robinson, Individual Skill Tests in Physical Activities, (Chicago, 1937), pp. 1-48.

ten second volley control test, a service return to a marked area in the back court and a back wall return to the front wall. Three of the five tests were used by Clevett in the 1935 study. The battery of tests was used as a method of measuring the achievement of the individual in his ability to play the game. It did not claim to measure all the factors involved in making a good handball player. The test was not used extensively, mainly because no statistical treatment was used to find the validity or reliability of the individual test items.

One of the most popular skill test batteries was introduced by Cornish[30] in 1949. Test subjects were derived from six physical education classess at Louisanna State University in Baton Rouge, Louisana. One hundred thirty-four subjects were tested. The test battery consisted of a thirty second volley to the front wall, front wall accuracy placement, back wall placement, service placement and a power test. During the last four weeks of the course, each student played twenty-three games. The multiple correlation of the five tests with the total number of plus points on games won was reported as .69. The highest individual correlation with the criterion was the power test, .58. The lowest correlation with the

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[3]Clayton Cornish, "A Study of Measurement of Ability in Handball", Research Quarterly, Vol. 20, No. 2, (May, 1949), pp. 215-222.

the criterion was the back wall placement having a correlation of .38. The lowest intercorrelation was the service placement test with the front wall and back wall placement, both revealing a correlation of .26. A combination of the thirty second volley and the service placement with the criterion had a correlation of .667. If only one test had been selected, the power test would have been the best, because of its correlation of .69 with the other tests.

McCrachen[4] developed a skill test battery for an outdoor one wall court at the University of Florida. He utilized fifty-six subjects enrolled in required physical education classes. The subjects were tested on a lob serve to a marked area, a kill shot placement to the front wall and a one minute continuous front wall volley. Reliability was derived by test and retest. The coefficient of reliability was .85. Test validity was determined by correlating the scores with the criterion established from a round robin tournatment. A multiple correlation was reported as .76.

Leinbach[5] proposed a test battery at the University of Texas, Austin, Texas, in 1952. He utilized fifty-seven

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[4]James R. McCrachen, "A Study of the University of Florida Handball Skill Test", (unpub. Master's thesis, University of North Carolina, 1949), pp. 1-29.

[5]C. H. Leinbach, "The Development of Achievement Standards in Handball and Touch Football For Use in the Development of Training for Men at the University of Texas, (unpub. Master's thesis, University of Texas, 1952), pp. 1-32.

students enrolled in two physical education classes. The test was conducted on a court which was considerably undersized. The dimensions of the court were seventeen feet wide, fourteen feet high and thirty-one feet long. The eight test items were front wall placement with the right and left hand, back wall placement with the right and left hand, cross court lob service, high wall service, power service and a coutinuous rally test up to thirty hits. The players were ranked according to the total number of points earned on the eight items. The rankings were correlated with the subjective rating of the players by the handball instructors. The resultant contingency coefficient for the non-parametric test was .72.

An alternate form of Cornish's thirty second volley was used by Simos[6] at Springfield College. This test battery in the chronological tracing utilized distances of five, eight and eleven feet from the front wall. The thirty-three students selected for the study were administered the test on an undersized court measuring nineteen feet in width, thirteen feet in height and thirty-one feet in length. The total number of points scored on the three item test was correlated with the subjective rating of the the instructors. The instructors' ratings revealed a

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[6]Thomas Simos, "A Handball Classification Test", (unpub. Master's thesis, Springfield College, 1952), pp. 1-21.

correlation of .59 between the round robin results and the test battery.

Griffith[7] conducted a study at Ohio State University in 1960. He utilized fifty-six subjects enrolled in required physical eduction classes. The three test items consisted of a sixty second volley test, a sixty second front wall and back wall test labeled a "free for all" and a penny cup test. (The penny cup is designed to test the speed and reaction of the participant. It is similar to the shuttle run, except the runner must place pennies in a cup for each shuttle run.) The results of the three tests were correlated with the standings in a round robin tournament. The highest correlation was found between the sixty second volley and the criterion, .71. The "free for all" test was discarded, because it proved to be too confusing to the subjects. The penny cup test which had proven to be valid in measuring basketball playing ability, yielded a low correlation in Griffith's handball study.

Another skill test battery was developed by four graduate students at the University of Oregon in 1967.[8] They used thirty-seven male undergraduate students. Other

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[7]Malcomb A. Griffith, "Can We Have an Objective Method for Evaluating Ability in Handball Singles?" (unpub. Master's thesis, Ohio State University, 1960), pp. 3-35.

[8]G. G. Pennington, James Day, John Drowatsky and John Hanson, "A Measure of Handball Ability", Research Quarterly, Vol. 38, No. 2, (May, 1967), pp. 247-253.

than the implementation of three strength tests and a measure of motor ability (shuttle run), the study was based on the test items Cornish introduced in 1949. The only modifications of the Cornish five item test were the differences in score recordings with the dominant and non-dominant hand for the thirty second volley, power test and front and back wall placement. In the games, a point was scored every time a failure occured. In other words, on each service either the server or the receiver scored a point. Service was changed in the normal manner. The games consisted of fifteen points. The total number of points earned during the ten games were computed into an average. The test items were as follows:

1. Thirty second wall volley either hand.
2. Thirty second wall volley with the non-dominant hand.
3. Total wall volley score.
4. Front wall placement test total.
5. Front wall placement test with dominant hand.
6. Front wall placement test with non-dominant hand.
7. Back wall placement test total.
8. Back wall placement with dominant hand.
9. Back wall placement with non-dominant hand.
10. Power test total.
11. Power test with dominant hand.
12. Power test with non-dominant hand.

13. Service placement test.

14. Thirty second shuttle run.

15. Total grip strength.

16. Grip strength with dominant hand.

17. Grip strength with non-dominant hand.

The highest zero order correlation obtained was .711 between the service placement test and the criterion. The second highest zero order correlation was .684 between the thrity second wall volley and the criterion. A multiple correlation of .80 between the criterion and the service placement, total wall volley and back wall placement was computed by the Wherry-Doolittle test selection method. In the conclusion of their report, they did not indicate the results of the strength tests or measure of motor ability. Nothing could be determined from these items. The investigators concluded that the service placement and the thirty second wall volley were the best predictors of handball ability.

The most recent skill test battery developed by Tyson[9] was the first to adapt the testing instrument to a regulation court measuring twenty feet high, twenty feet wide and forty feet in length. He utilized sixty-four college students who had completed a formal course of handball instruction. The test items consisted of a thirty second

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[9]Ken Tyson, "A Handball Test for College Men", (unpub. Master's thesis, University of Texas, 1970), pp. 1-42.

volley and the six dominant and non-dominant skills of kill placement, ceiling and back wall kill placement returns. The criterion was a round robin tournament. The player's score for all the matches he had played were added together and averaged. The points scored against the player by each of his opponents were also added together and averaged. The average score and the difference determined the rank order of the players in each class. Before computing a multiple correlation, Tyson correlated each skill test with the criterion by using a product-moment correlation. He then selected the four skill tests which produced the highest correlation (volley test and the dominant front kill, back wall kill and ceiling return) for comparison with the criterion in the multiple correlation. The multiple R was reported as .92. The only questions concerning the Tyson study are the fact that not all subjects were tested and it was not indicated how the subject from the various classes were equated in ability.

Subjective Systems

In 1937, Friermood[10] developed a handball classification plan. The plan was used to classify players for competition in Y.M.C.A. tournaments. The instrument

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[10] H. T. Friermood, "A Handball Classification Plan", Journal of Health and Physical Education, Vol. 8, No. 1, (February, 1937), pp. 106-107.

categorized players into three groups relative to their knowledge of the game, physical characteristics and playing ability. The classification was a subjective rating of the following ten items:

1. General physical appearance and age.
2. Knowledge and experience.
3. Past record of wins and losses.
4. Court tactics and game strategy.
5. Type of game played.
6. Use of both hands in a variety of shots.
7. Footwork.
8. Speed and strength.
9. Interest in the game.
10. Sportsmanship.

Another subjective rating system was introduced by Schiff[11] in 1938. The subjects were evaluated by observations. Schiff used three assistants schooled in the system of checking the success of each player. The ratings by each assistant were totaled and averaged for each student. He reported a correlation of .87.

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[11] F. S. Schiff, "A Test of Skills Performed in the Game Situation of Handball", (unpub. Master's thesis, Ohio State University, 1938), pp. 1-20.

Classification According to Modified Tournaments

Montoye and Brotzman[12] used the results of a doubles tournament as an index of playing ability in handball. The players were matched at random. Fifty-two subjects at Michigan State University were selected for the study. One third of the group participated in a singles tournament, (commonly considered a valid measure of handball ability if there are a large number of players), while the other two thirds were placed in a doubles tournament. Eleven games were played. The results of the doubles match were correlated with the results of the singles match. Four different methods of computing a handball ability index were investigated. They consisted of percentages of games won, average score per game, total score made in all games minus total score of opponents and average score per game minus average score of opponents. Coefficients of correlation ranging from .641 to .840 were secured. The percentage of games won produced the lowest correlation. The investigators concluded that a doubles handball tournament is a valid measure when many games are played; players are ranked as in singles, teams are randomly selected and no

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[12]Henry J. Montoye and John Brotzman, "An Investigation of the Validity of Using the Results of a Doubles Tournament as a Measure of Handball Ability;" Research Quarterly, Vol. 22, No. 1, (March, 1961), pp. 214-218.

two players form a team more than once. The best measures are the total difference or average difference scores.

In 1963, Bischoff[13] studied the use of the ladder tournament as a method of determining the ability level of the individual player. Members in the class were randomly selected for doubles teams. On a given day, a doubles match was played between two teams. After the doubles match, each member of the team played a member from the opposing team in a game of singles. The scores were posted on the doubles and singles chart. Every time a team won, they were moved up on the ladder for doubles competition. When an individual won, his name was moved up on the singles ladder. No attempt was made to test the reliability or validity of this method. Objectivity, grading and motivation of the students was the only desired outcome of this method.

Duration and Type of Training

One investigator even challenged the duration of the school term as a measure of handball achievement. A comparative study was conducted at the University of Florida between the trimester system and the semester system

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[13]David C. Bischoff, "A Skill Grading System Using a Modified Ladder Tournament," Journal of Health, Physical Education and Recreation, Vol. 34, No. 4, (April, 1963), pp. 10-11.

by Waglow.[14] The purpose of the study was to determine if skill achievement in three activities, based on grades, would be the same in fifteen weeks of instruction as it was in a seventeen week instructional program. To compensate for reducing the length of the semester from seventeen weeks under the semester system to fourteen weeks under the trimester system, each class period was extended by five minutes. In theory, there was an equalization of instructional time under each system.

Data were collected in 1958 for the semester system and in 1964 for the trimester system. Standardized skill tests were used for the activities of tennis, golf and handball. (The investigator did not indicate the type of standardized tests. Apparently, they were developed by the University of Florida.) The results of the two systems were compared by a t test for significance of difference. Neither the number of the subjects nor their selection was reported. The investigator indicated that it was impossible to equate the ability of the groups.

The results were a t of 7.04 for tennis, 5.66 for golf and 1.73 for handball. The t's of 7.04 and 5.66 were significant beyond the .01 level of confidence. The t of 1.73 for handball was not significant. The investigator concluded that in light of the findings, handball can be

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[14] I. F. Waglow, "Effect of School Term Length on Skill Achievement in Tennis, Golf and Handball," Research Quarterly, Vol. 37, No. 2, (May, 1966), pp. 157-159.

taught and skills developed in a much shorter time than tennis or golf. One must certainly question the conclusion based on the time span between the comparative samples and the investigator's statement that five minute extensions equalized the instructional time under both systems.

Railey[15] conducted a study to investigate the effectiveness of three training methods on the improvement of performance in handball serving skill. (If you will recall, two studies have already revealed the service as a valid instrument in prediciting the success of a player in a game.) The training approaches consisted of imitative resistance exercise, direct practice and a combination of imitative resistance and direct practice. The investigator was primarily concerned with the speed and accuracy of a served handball. He utilized sixty-four members from five sections of beginning handball at Weber State College. The subjects were all volunteers. They were assigned to three treatment groups. Each group exercised three days a week for a period of eight weeks.

The imitative exercise group (IR) used the Exer-Genie and imitated the sidearm handball serve. The subject isometrically pulled against the apparatus for eight seconds. Each subject in the group completed two sets of ten

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[15] Jimmy H. Railey, "Effects of Imitative Resistance Exercises and Direct Practice on Handball Skill," Research Quarterly, Vol. 41, No. 4, (December, 1970), pp. 523-527.

repititions with a one minute rest between sets. The direct practice group (DP) hit twenty serves to a point fifteen feet from the front wall. The third group (IR-DP) combined imitative resistance and direct practice. They performed half the number of the first two groups. A storage oscilloscope measured handball velocity and a painted target with gradation of scores measured accuracy.

The findings, computed by AOV, revealed the following: (a) no significant difference was found among treatment groups for handball serving speed and accuracy, (b) all experimental groups experienced significant and comparable gains in serving speed, and (c) there was no significant loss in serving speed or accuracy as a result of the treatment period. The investigator concluded that resistive exercises are not superior to direct practice training programs in developing the handball service.

Reaction Time, Performance Time and Handball Velocity

In 1968, Yeo[16] studied the relationship of reaction time, performance time and linear velocity of a handball to success in playing the game. The investigator concluded that the player with the most ability in handball will

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[16]David, G. Yeo, "The Relationship of Reaction Time and Handball Velocity to Success in Handball," (unpub. Master's thesis, Springfield College, 1968), pp. 1-50.

demonstrate faster reaction time of the non-dominant foot, faster handball velocity of the dominant hand and a faster performance time of the dominant hand. This conclusion was reached from the data collected from the Dekan Performance Analyzer. The results were computed by multiple correlation with the criterion established from fourteen players who competed in a round robin tournament. The multiple R was .65.

Mechanics of the Best Handball Stroke

A study designed by Holt[17] compared the straight arm stroke and the elbow flexion-extension stroke in relation to handball velocity, time required to execute each stroke and the distance the striking hand travels during the propulsive phase of each stroke. The Hale Reaction Performance Times was used to measure handball velocity. Data for the remaining variables were obtained through cinematographical analysis. Eleven experienced players at Springfield College were selected as subjects. The purpose of the study was to determine which arm hand action is the most effective in playing handball.

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[17]Laurence E. Holt, "A Comparative Study of Selected Handball Techniques," Research Quarterly, Vol. 40, No. 4, (December, 1969), pp. 700-703.

A comparison of the two techniques, computed by a t test, yeilded a significant difference in favor of the flexion-extension method. The velocities achieved by the flexion-extension stroke were between 90-100 feet per second as compared to 65-78 feet per second for the straight arm stroke. The time required to execute the stroke and the distance the hand travels during the propulsive phase were .8 to .10 seconds and 4 to 6 feet respectively for the flexion-extension stroke and .25 to .30 seconds and 8 to 9 feet respectively for the straight arm stroke. Film analysis also revealed that there is a much greater leverage superiority for the flexion-extension technique. The investigator concluded that the player who uses the flexion-extension stroke has more time to reach the ball and set himself up for the stroke and as a result will have time to plan game strategy more effectively.

Summary

After reviewing the literature, it was apparent that a reliable, objective and valid measure of an individual's ability in handball based on the skills which are essential to the game has still not been established.

Of all the skill items which have been proposed and tested in the last thirty-seven years, only the thirty second volley and the service placement have merited consideration due to replication and mutual results. In

light of the recent emphasis on the "kill" as the major offensive skill, control of the ball and the power pass as the major defensive skills, inclusion into a comprehensive test battery seems vital. The investigator maintains that it can be safely assumed that the ability to put the ball into play in a particular area of the court and consecutive returns to the front wall with the preferred hand does not provide the evaluator with sufficient evidence of a player's handball playing ability.

Other measuring devices such as modified tournaments and the use of qualified subjective evaluators are also questionable practices. In the first method, there is an attempt to predict how well a player will do in a tournament based on a quick evaluation instrument. If we use the results of one tournament to predict the player's performance in another, we cannot justify the use of the first tournament. In the second method, how do we establish the criteria for a qualified subjective evaluator?

The studies which have reported high correlations in relation to the proper mechanics of the stroke, performance and reaction times is important to an instructor as well as the player. However, getting to the ball quickly and swinging with the proper mechanics does not insure that the ball will actually be hit to the desired destination. The major predictor of the player's performance in the game is

based on the skills which he possesses and these skills must be important in the game of handball.

The researchers who have designed the skill test batteries for handball reported in the literature have overlooked the guidelines of a good test. First, many of the test items which were selected, such as the service placement, required elaborate court markings and a great deal of testing time. A Physical Education teacher in a handball activity class cannot afford to allot the time they have required for preparing a testing station. Secondly the preparation of a court reduces the number of subjects who can be evaluated at the same time. Thirdly, the time allocation for testing should be no more than seven or eight minutes for each subject and all available handball courts should be used. Lastly, in most studies, a regulation court was not utilized for testing and some advanced skills were used to evaluate beginning players.

The skill test battery which the investigator utilized in this dissertation only required one line twenty-four inches from the floor, a line six feet from the back wall and seven and one-half minutes of testing time. Any standardized court could be utilized for testing purposes.

CHAPTER III

METHODOLOGY

This chapter describes the various procedures, selection of the criterion and selection of test items that were utilized during the investigation.

Subjects

The subjects for this investigation were one hundred two male college students enrolled in P.E.M. 134 (Beginning Handball) at the University of Illinois, Chicago Circle during the Winter Quarter of 1973. The subjects were selected from six physical education classes. The classes met two days a week for ten weeks and each class period was sixty minutes in length. There were approximately twenty players in each class. Ages ranged from eighteen to twenty-four years of age. Although everyone competed in the tournament and was subjected to the skill test battery, the highly skilled registered in each section were eliminated from the study. The elimination was based on the skilled judgement of the instructor. It was the intent of the investigator to select those students whose playing abilities were as comparable as possible.

Equipment

The items required for the skill test battery were as follows:

1. Seamless 555 handballs (10).
2. Score cards for recording results (240).
3. Pencils (5).
4. Yardstick (1).
5. Black plastic electrical tape 3/4" (2 rolls).
6. Stopwatches (5).

The items required for the round robin tournament were as follows:

1. Seamless 555 handballs (5).
2. Round robin tournament sheets (6 sets).
3. Round robin results sheets (6 sets).
4. Pencils (5).

General Procedures

January 8, 1973 was the first day of class for the six handball sections. On that day, a letter, prepared by the investigator, was read to each class by the instructor. (See Appendix A.) For the first four weeks, the students received basic instruction in handball skills. The last class date of the fourth week was utilized for a written test on the rules of the game and the skills which had

been introduced. None of the students or instructors were aware of the skill test items in the battery.

After the end of four weeks of instruction, the subjects participated in a five week partial round robin tournament. On each class date during the five week period, three fifteen minute matches were scheduled. A match was a continuous game between two players. Each player competed in two matches each class period.

During the tenth week of the course, the test battery was administered to the subjects. The test was administered twice, during consecutive class periods, by two different examiners to each subject to determine the reliability and objectivity of the test items. On the first day of the tenth week, the subjects were given a written description and a visual demonstration of the eight items in the battery. After the preliminary orientation, the subjects were randomly assigned to a test examiner in one of five handball courts. Since each class was examined independently, each test examiner was only responsible for four subjects. After the subjects were assigned to their courts, each group of four were allowed to practice the test items for five minutes. The examiner was available to answer any questions regarding the test items. When the individual testing began, only the subject and the examiner were allowed in the court. One test item was administered at a time to a subject, before the second subject replaced the first

in the court. The entire test battery followed the same procedure. For the second test battery, the subjects were randomly assigned to different examiners. A new result sheet was given to the examiner for the second battery, so he would not know the results of the first test.

Research Assistants

The examiners selected for test administration were majors in Physical Education at the University of Illinois, Chicago Circle. Two days prior to test administration each examiner was given a written description of the test items and a visual demonstration by the investigator. After the preliminary orientation, the test battery was administered to the examiners. As one examiner attempted the skill, another examiner practiced the administrative method.

Location

The tournament and test administration was conducted in the first five courts of the new Physial Education Building at the University of Illinois, Chicago Circle located in downtown Chicago.

Preparation of the Court for the Study

The only preparation necessary in the five courts was the placing of black plastic 3/4" electrical tape across the fron wall twenty-four inches from the floor and six feet from the back wall on the floor. (See Figure 1.)

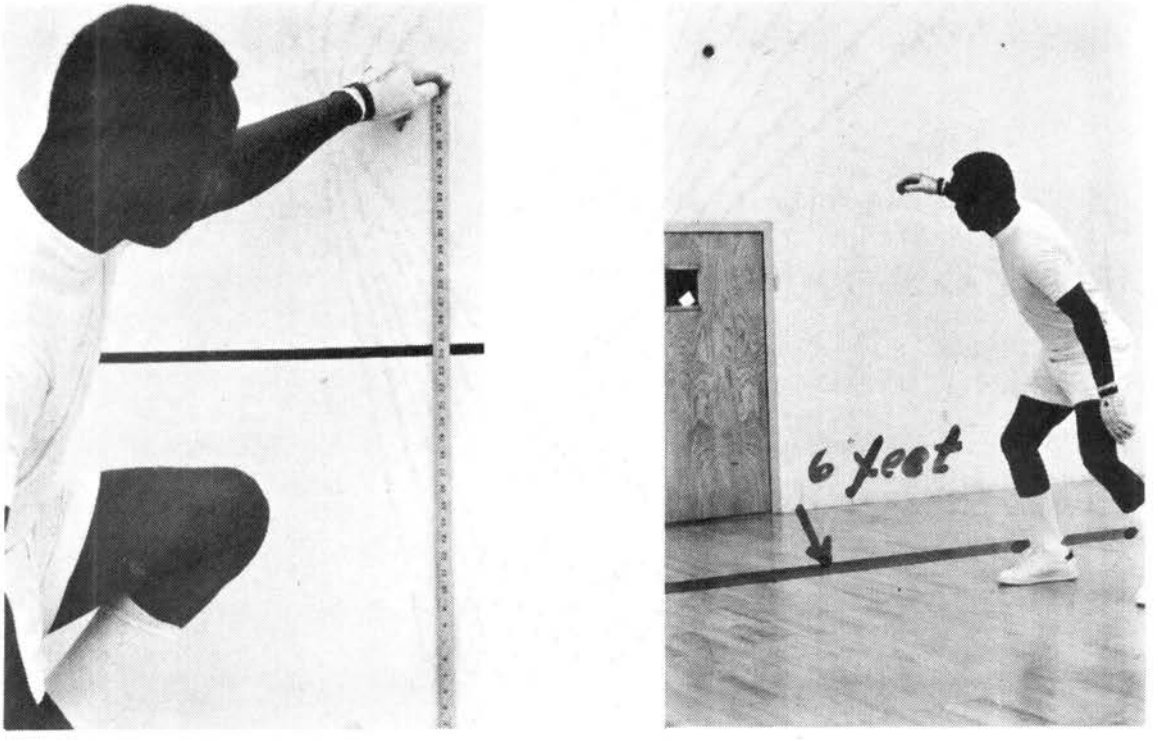

Figure 1. Preparation of the Courts

The remainder of this chapter is concerned with the rationale for selecting the criterion and the test items

in the battery. Attention is also focused on the procedure for plotting scores.

Criterion of Validity

In order to determine the validity of a test, an acceptable criterion with which to compare the scores obtained from such a test had to be established. As McCloy stated, "It is often easier to determine what should be measured than to develop a criterion which adequately presents it."[1]

There have been several types of criteria which have been used in the construction of skill tests. The test items might be compared with (1) previously validated tests, (2) results of a round robin tournament, (3) subjective ratings of qualified judges, or (4) divergent groups procedure. Scott[2] claims that judges ratings are the most common type of criterion used, but is often criticized because it introduces the element of subjectivity. Willgoose favors a round robin tournament as the best indication of playing ability in individual and dual sports. He states, "Individual achievement in a game like handball

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[1]Charles McCloy, Test and Measurements in Health and Physical Education, (New York, 1942), p. 307.

[2]M. Gladys Scott and Esther French, Measurement and Evaluation in Physical Education, (Iowa, 1959), pp. 81-84.

can be best checked by the individual's standing when a round robin tournament is finished."[3] The tournament criterion has been used successfully in such valid skill test batteries as Dyer's[4] tennis test and Miller's[5] badminton test.

The criterion of a partial round robin tournament was selected for this study because the investigator sought the following:

1. An objective measure for comparison with the test battery.
2. A greater range of differences between the subjects.
3. Performance which was based on actual game situations.

As previously mentioned in the general procedures, the partial round robin tournament started after the fourth week of basic instruction. In (Figure 2), the letters represent the subjects and the numbers represent the tournament day on which the match was played. Since the class met twice a week, the tournament lasted for ten class days.

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[3]Carl E. Willgoose, Evaluation in Health Education and Physical Education, (New York, 1961), p. 233.

[4]Joanna T. Dyer, "The Backboard Test of Tennis Ability," Research Quarterly, Vol. 6, (March, 1935), pp. 63-74.

[5]Francis A. Miller, "A Badminton Wall Volley Test," Research Quarterly, Vol. 22, (May, 1951), pp. 208-213.

Matches for a given day were readily apparent by reading diagonally from the lower left corner to the upper right corner on the illustration.

The results of the matches were plotted on the tournament result sheet illustrated in (Figure 3). Reading from left to right, the subject's score for each match is placed on the left side of the square and the opponent's score is placed on the right. The players attempted to earn as many points as possible during each fifteen minute match. The total number of points earned by a subject for all the matches played during the five week tournament were compared to the total number of points earned by the opponents in the matches played with that subject. If the subject's total point score was greater than the cumulative total of points earned by the subjects he competed against, a plus score resulted by subtracting the opponent's total from the subject's total. However, if the opponent's total score was higher than the subject's cumulative total, a minus score resulted by subtracting the subject's total from the opponent's total. The scores were adjusted to eliminate the minus values by using the lowest minus score in the tournament as a one.

The following guidelines were used in the conduct of the round robin tournament:

1. United States Handball Rules were enforced. The only exception was the use of a fifteen minute time for each match.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
A		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9
B			3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	2
C				5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	1	4
D					7	8	9	10	1	2	3	4	5	6	7	8	9	1	2	6
E						9	10	1	2	3	4	5	6	7	8	9	1	2	3	8
F							1	2	3	4	5	6	7	8	9	1	2	3	4	10
G								3	4	5	6	7	8	9	1	2	3	4	5	2
H									5	6	7	8	9	1	2	3	4	5	6	4
I										7	8	9	1	2	3	4	5	6	7	6
J											9	1	2	3	4	5	6	7	8	8
K												2	3	4	5	6	7	8	9	1
L													4	5	6	7	8	9	10	3
M														6	7	8	9	10	1	5
N															8	9	10	1	2	7
O																10	1	2	3	9
P																	2	3	4	1
Q																		4	5	3
R																			6	5
S																				7
T																				

Figure 2. Round Robin Tournament Schedule

ROUND ROBIN TOURNAMENT RESULTS SHEET CLASS_____

SUBJECT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Subject's Cum. Score	Opponent's Cum. Score	Adjusted Score
A																							
B																							
C																							
D																							
E																							
F																							
G																							
H																							
I																							
J																							
K																							
L																							
M																							
N																							
O																							
P																							
Q																							
R																							
S																							
T																							

Figure 3. Tournament Result Sheet

2. All matches started and stopped by a whistle blast from the instructor.
3. A player who was absent for a scheduled match was required to play the match during a make up period on the succeeding day. One extra court was allocated for make up games.
4. The instructor determined the player who put the ball in play be a service. Each player had an equitable opportunity to serve first.

Validity of the Test

When one speaks of measurement, the question is asked about any particular test, "Is the test valid?" The answer should be in the form of another question, "Is it valid for what?"[6] In this study, the investigator attempted to determine if a particular test battery was valid for predicting the success of a player in a handball game.

Construction of a test battery and its usefulness as a measure of ability is subject to a guiding principle according to Sheehan. He claims, "Unless a test is valid, reliable and economical, it is of very little use in an

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[6]J. P. Guilford, Fundamental Statistics in Psychology and Education, (New York, 1965), p. 471.

educational evaluation program."[7] The American Association of Health, Physical Education and Recreation also asserts, "A high degree of objectivity in making observations is also necessary if the data are to be valid."[8] In order to control the variables associated with threats to internal validity and achieve consistency and objectivity in measurement, the following procedures were observed:

1. All subjects were tested during approximately the same time of day.
2. Motivational factors were limited by testing one subject at a time from each of the testing groups. No observers were present during the actual test.
3. All subjects were randomly assigned to testing groups.
4. Experimental mortality was not a factor, because the subjects were tested during the final week of the quarter.
5. Every subject was tested twice. Each subject was administered the second test by a different examiner.

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[7]Thomas J. Sheehan, An Introduction to the Evaluation of Measurement Data in Physical Education, (Reading, Massachusetts, 1971), p. 47.

[8]American Association of Health, Physical Education and Recreation, Research Methods in Health, Physical Education and Recreation, (Washington, 1959), p. 104.

Selection of the Test Items

With the criteria of validity, reliability and objectivity in mind, the investigator proceeded by considering the steps of skill test selection. According to Matthews,[9] skill tests in physical education activities are constructed by adherence to the following outline:

1. Critically examine the sport to determine the skills most essential for successful performance in the activity.
2. The variables selected for measurement are administered as a test to a large sample of subjects to whom the results are applied.
3. The final step is to ascertain whether those who scored high on the test were also the better players. If the subject's scores on the test prove to be closely related to the number of points earned in a round robin tournament, the test may be considered valid.

Since the criterion had been established by incorporating a partial round robin tournament and the subjects have been determined, only the test items which closely resembled the skills most essential for successful performance in handball needed to be selected. Literature concerning the skills involved in the game of handball

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[9]Donald K. Matthews, Measurement in Physical Education, (Philadelphia and London, 1963), p. 162.

generally agree that there are five skills involved in the game. The source which was cited to substantiate the claim is by Michael Yessis.[10] The Yessis book, as part of the Brown Physical Education Activities Series, is one of the most popular books used by College and University physical education departments for the handball activity course. The skills are the service, front wall kill placement, back wall return, control volley and overhand, sidearm and underarm returns. Successful performance is prefaced on the assumption that the ball can be hit with either hand.

Based on the literature available with relation to the essential skills involved in successful performance, eight test items were devised for the study. The items were (1) dominant overhand return, (2) non-dominant overhand return, (3) dominant front wall kill placement, (4) non-dominant front wall kill placement, (5) thirty second alternate hand volley, (6) dominant hand thirty second volley, (7) non-dominant thirty second volley and (8) one minute continuous back wall volley.

Description of the Test Items

Presented in this section is a description of the test items with pictorial illustration. (The model in the figure is a right handed player.)

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[10]Michael Yessis, Handball, (Iowa, 1966), pp. 4-42.

1. Dominant Overhand Return

In this test, the subject will stand between the short and service lines. After the subject bounces the ball on the floor high enough so that he will contact the ball with an extended elbow, he will attempt an overhand delivery with his dominant hand. The ball must be hit with sufficient power so that it will hit the front wall and then the back wall without touching the floor between the two walls as illustrated in Figure 4. Side arm hits or ball contacted without an extended elbow will be counted as unsuccessful attempts. Only the successful attempts out of ten trials will be recorded. The subject is not allowed to cross the service line in his attempt to hit the ball.

2. Non-Dominant Overhand Return

In this test, the subject will stand between the short and service line. After the subject bounces the ball on the floor high enough so that he will contact the ball with an extended elbow, an overhand shot with the non-dominant hand will be attempted. The ball must be hit with sufficient power so that it will hit the front wall and bounce no further than six feet from the back wall. The procedure and six foot line is illustrated in Figure 5. Side arm hits or balls contacted without an extended elbow will count as unsuccessful attempts. The player is not allowed to step

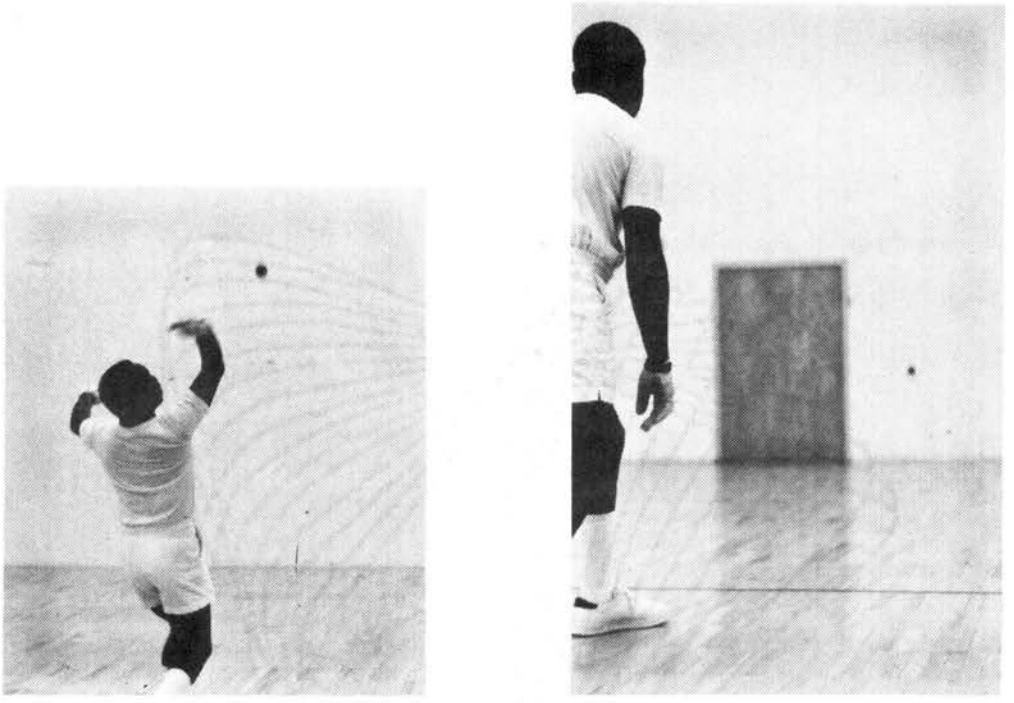


Figure 4. Dominant Overhand Return

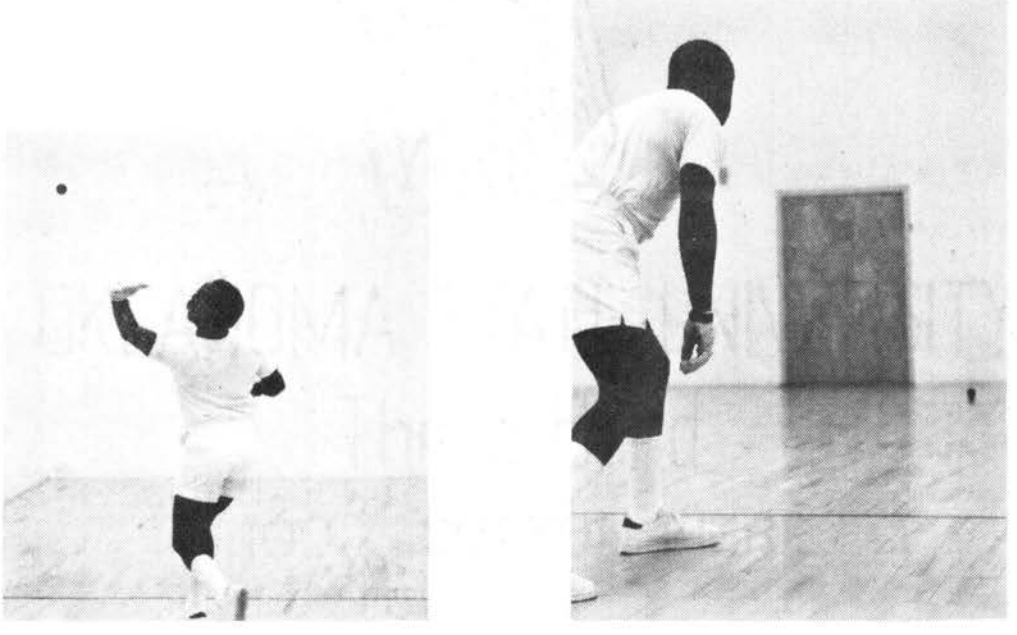


Figure 5. Non-Dominant Overhand Return

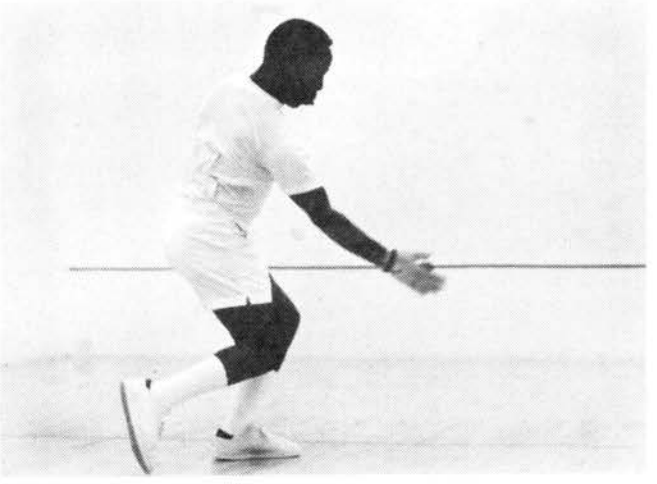
over the service line in his attempt to contact the ball. Only the successful attempts out of ten trials will be recorded.

3. Dominant Front Wall Kill Placement

The subject will stand between the short and service lines in the center of the court facing the right side wall. After the subject lobs the ball to the side wall on a fly, he will move into position of the ball returning from its arc after a bounce on the floor and attempt a front wall kill placement with the dominant hand. The ball must hit the front wall between the baseline and black line located 24 inches up from the floor. (See Figure 6.) A ball which hits the floor, is missed or hits above the black line will be counted as an unsuccessful attempt. (A ball which touches any part of the twenty-four inch line will count.) The player is not allowed to step across the service line. Only the successful attempts out of ten trials will be recorded.

4. Non-Dominant Front Wall Kill Placement

The procedure and number of attempts are synonymous with test three except the non-dominant hand will be used as illustrated in Figure 7. Only the successful attempts will be recorded.



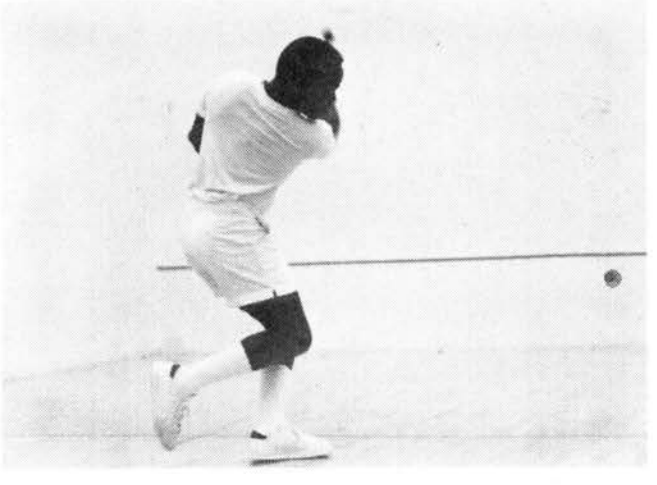


Figure 6. Dominant Front Wall Kill Placement

5. Thirty Second Alternate Hand Volley

The test begins by having the subject stand between the short and service line facing the front wall. On the signal, the ball is thrown to the front wall by the subject. After the ball bounces on its return from the front wall, the subject will attempt to deliver the ball back to the front wall at an angle that will cause the ball to return to the subject's opposite side for an alternate hand return. (See Figure 8.) If the ball is hit with the same hand on two successive returns, a point will not be rewarded. If the ball is not returned to the front wall or missed, the test examiner will throw the subject another ball. The points which have been earned from previous volleys before the missed attempt will be added to successful points earned in succeeding attempts. The player is not allowed to step across the service line in returned the ball. At the end of thirty seconds, the total number of alternate hits will be recorded.

6. Dominant Thirty Second Volley

The procedure will be the same as test 5, but only the dominant hand will be utilized as illustrated in Figure 9.

7. Non-Dominant Thirty Second Volley

The procedure will be the same as test 5, but only the non-dominant hand will be utilized as illustrated in Figure 10.

8. One Minute Continuous Back Wall Volley

In this test, the subject is allowed to use the dominant hand exclusively if he wishes. On the signal, the subject will serve the ball to

the front wall while standing between the short and service line. He will then attempt to return his own service after the ball bounces into the back wall. The return must be directed to the front wall with sufficient power so the ball will rebound into the back wall for another return. Each succeeding shot will have the same purpose. (See Figure 11.) When the subject fails to successfully return the ball, he will be given another ball and return to the service area to begin again. After one minute, all of the successful attempts will be recorded.

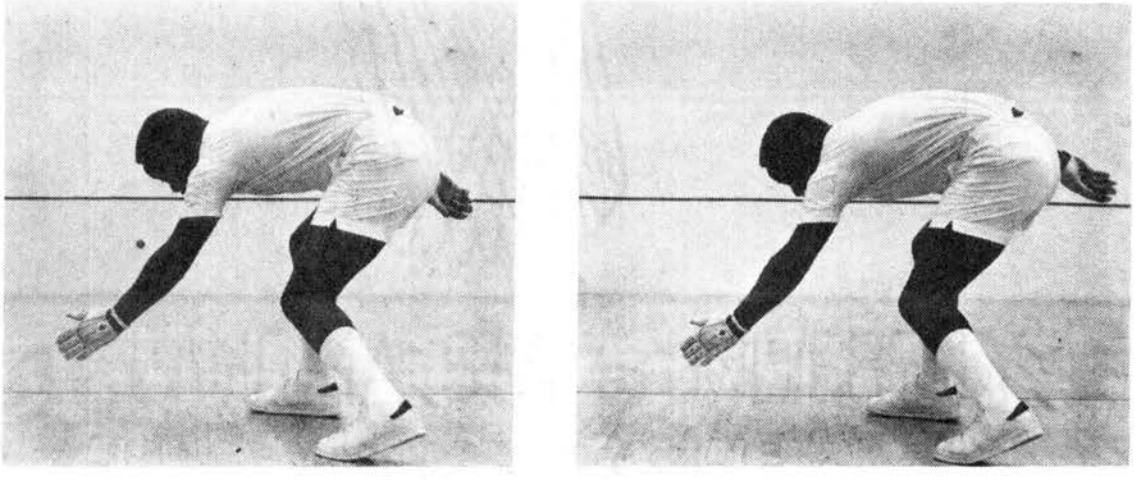


Figure 7. Non-Dominant Front Wall Kill Placement

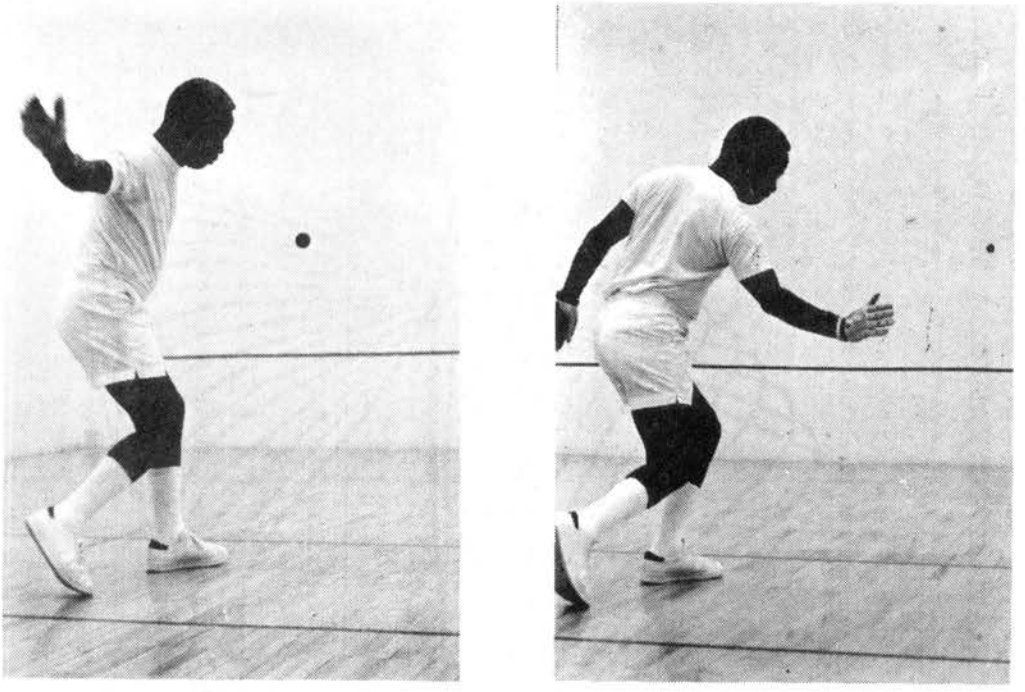


Figure 8. Thirty Second Alternate Hand Volley

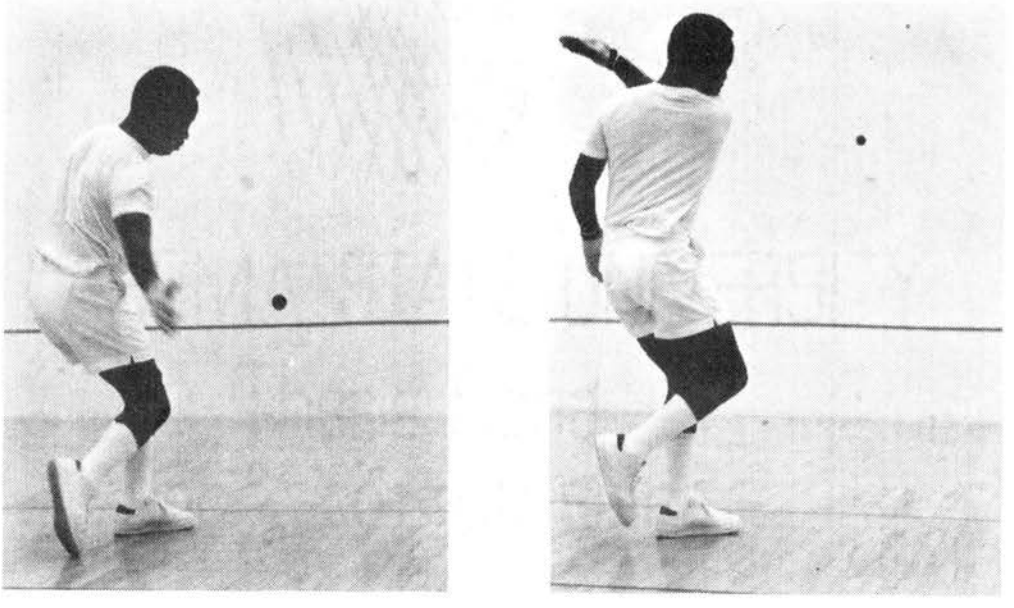


Figure 9. Dominant Thirty Second Volley

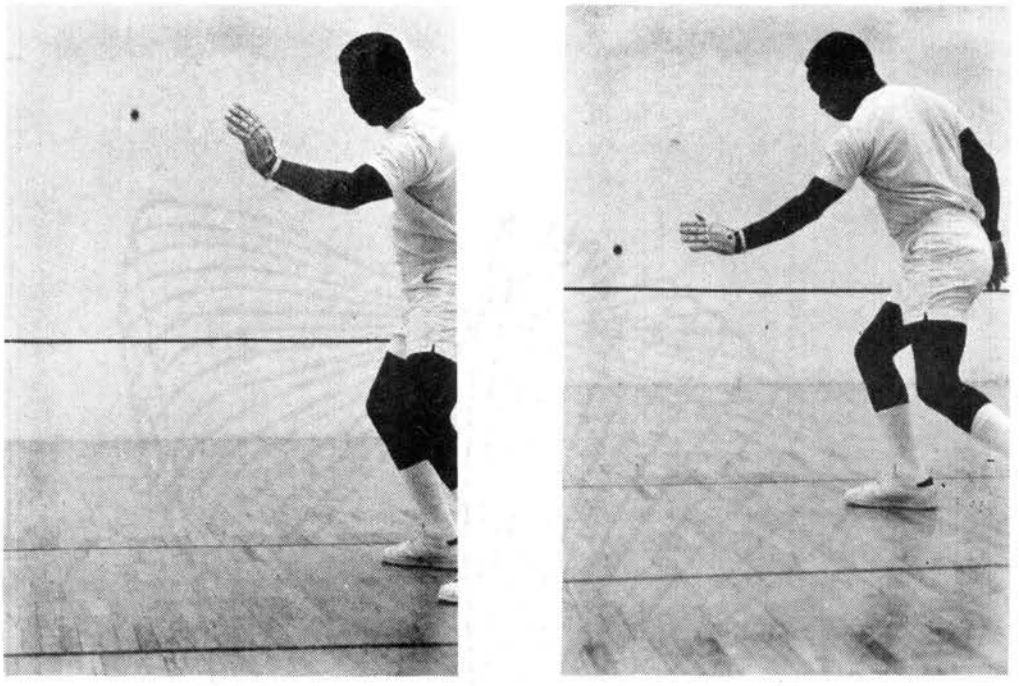
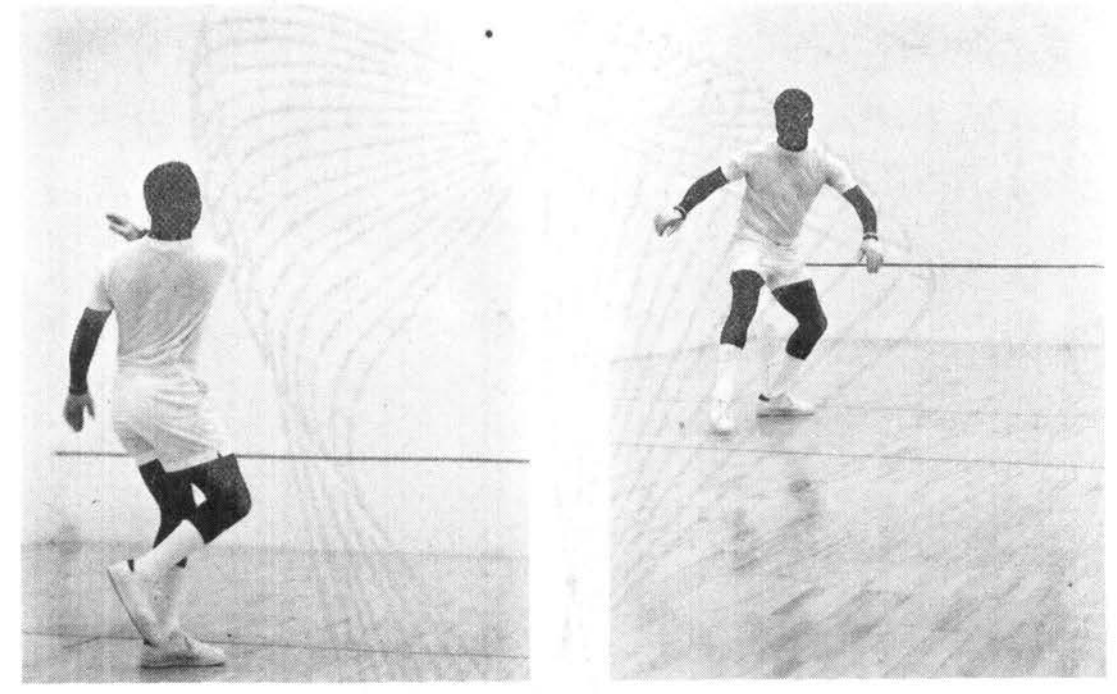


Figure 10. Non-Dominant Thirty Second Volley



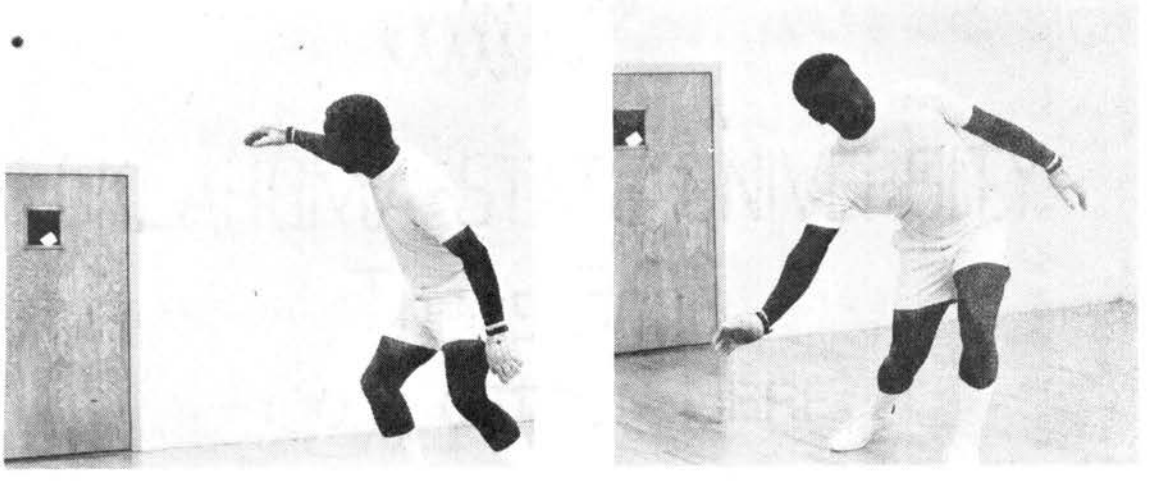


Figure 11. One Minute Continuous Back Wall Volley

The results of the entire test were recorded on each subject's individual score card (Figure 12).

Subject Information Sheet

Subject _____ Time, day & section _____

Instructor _____ Date _____ Test No. _____

Test Items:	(Place tallies) Success	Failure	Numerical Score
1. Dominant Overhand Return (10 trials)	___	___	___
2. Non-dominant Overhand Return (10 trials)	___	___	___
3. Dominant Kill Placement (10 trials)	___	___	___
4. Non-dominant Kill Placement (10 trials)	___	___	___
5. 30 Second Alternate Hand Volley	___	___	___
6. 30 Second Dominant Hand Volley	___	___	___
7. 30 Second Non-dominant Hand Volley	___	___	___
8. One minute Back Wall Volley	___	___	___

Test Administrator _____

Figure 12. Score Card

Computation of the Results

Before analyzing the data of the study, the investigator deemed it necessary to check the comparability of the six classes. This was analyzed by computing the mean and standard deviation of each class on total test score and then using the parametric statistical technique of analysis of variances. The formula is found in Appendix B.

Reliability of the test items in the battery was determined by a test-retest technique on each item. The investigator expected a reliability coefficient of .85 or higher. On test items related specifically to accuracy the reliability coefficient was expected to be .70 or higher.

The data from the study was analyzed by O.S.U. computer program BMD-02R (Step Wise Regression). The program yielded the reliability correlations, individual test item correlations with the criterion, an intercorrelation matrix, multiple correlations and selection of the best test items in the battery. Once the battery was selected, a Wherry-Doolittle was computed by a hand calculator for a test battery of the top five items and the top three items. Beta weightings were derived for the test items in each of the proposed batteries. Regression equations and conversion values were then developed for each test item within the two proposed test batteries.

CHAPTER IV

ANALYSIS OF DATA AND DISCUSSION OF RESULTS

The purpose of this study was to develop a skill test battery which could be used to predict the ability level of a player in a handball game. The selection of the criterion of a partial round robin tournament, the determination of the essential skills in playing the game and the description of test items used in measuring proficiency were discussed in the preceding chapter. This chapter will relate specifically to the analysis of the comparability of the testing groups, reliability of the individual test items and a step wise regression to determine the best test items for the battery.

Comparability of the Test Groups

The one hundred two subjects selected for the study were from six physical education classes. The test battery was administered to all subjects and everyone competed in a partial round robin tournament, since the subjects only competed against those subjects in their respective class and not against every other subject in the study.

Owing to the fact that a one hundred one match round robin tournament was not possible, the investigator wanted to determine if the subjects in the six classes were comparable in ability. This was analyzed by computing the mean and standard deviation of each class on total test score and then using the parametric statistical technique of analysis of variance. Normally, certain assumptions must be met before a parametric test can be used. According to Kerlinger,[1] there are three assumptions underlying the use of analysis of variance. They are the normality of the population, homogenity of variance and equality of intervals. Since the subjects were not randomly assigned to the six classes, the assumption of normality was questionable. On the other hand, the lack of random assignment was not subject to the control of the investigator. The intent was to statistically analyze the variance between the six groups of subjects rather than to merely report that it could be assumed that the variance was neglibible and the groups were comparable. In relation to normality and heterogenity, Lindquist says, "Unless variances are so heterogeneous as to be readily apparent, that is, relatively

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[1]Fred N. Kerlinger, Foundation of Behavioral Research, (New York, 1964), p. 257-259.

large differences exist, the effect on the F test will probably be negligible."[2] Boneau says, "In a large number of research situations the probability statements resulting from the use of t and F tests, even when these two assumptions are violated, will be highly accurate."[3] In the final analysis, Kerlinger states, "It is probably safer and usually more effective to use parametric tests rather than non-parametric tests."[4]

The results of the analysis are found in Table 1. The findings indicate that there was no significant difference between the six handball sections involved in the study. An F value of .34 is not significant at the .05 level of confidence. The criterical value for the .05 level is 2.00. It was assumed that the six classes of subjects were comparable in ability.

Reliability and Objectivity

In order for a test to be valid, it must be reliable. More specifically, a test should yield approximately the same results each time it is administered. In like manner,

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[2]E. Lindquist, Design and Analysis of Experiments, (Boston, 1953), pp. 78-86.

[3]C. Boneau, "The Effects of Violations of Assumptions Underlying the t Test," Psychological Bulletin, LVII, (1960), pp. 49-64.

[4]Kerlinger, p. 259.

TABLE I

MEAN, STANDARD DEVIATION AND ANALYSIS OF VARIANCE FOR SIX CLASSES

Handball Section	Subjects	Mean of Test Scores	Standard Deviation
1	1 - 17	57.7	19.38
2	18 - 34	55.8	14.37
3	35 - 51	56.7	14.15
4	52 - 68	60.64	15.31
5	69 - 85	53.9	17.90
6	86 - 102	54.9	14.6

Source	ss	dx	n.s.	F	p
Total	27,172	101	___	___	___
Between Groups	475	5	95	.34	ns
Within Groups	26,697	96	278	___	___

consistency of measurement should occur regardless of the invididual administering the test. This is the measure of objectivity.

There are several techniques which are available for determining the reliability of a test. The most common types fall into three categories: Internal consisistency

reliability, alternate forms and test-retest reliability.[5] Since the first two methods are most commonly used with written tests, the test-retest was selected for this study. The procedure for the test-retest is to administer the test twice to each subject and then compute the reliability coefficient. For this investigation, all of the subjects in each class were administered the test battery of eight items during a single class period. During the next class period two days later, the same test battery of eight items was readministered to the subjects. Correlations of the test-retest procedure were determined by the computation of a product-moment correlation (r). Reliability correlations for the eight test items in the battery are presented in Table II.

According to the American Association of Health, Physical Education and Recreation,[6] the accepted standard of test reliability is .85. However, they also claim that certain tests, especially measures of accuracy, are known to have low reliabilities and .70 has been set by many investigators as the minimum acceptable standard.

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[5]American Association of Health, Physical Education and Recreation, Research Methods in Health, Physical Education and Recreation, (Washington, 1959), p. 234.

[6]Ibid, p. 246-248.

TABLE II

RELIABILITY CORRELATIONS

Test Items	Correlation
Dominant Overhand Return	.89
Non-Dominant Overhand Return	.43
Dominant Front Wall Kill Placement	.79
Non-Dominant Front Wall Kill Placement	.88
Thirty Second Alternate Hand Volley	.90
Dominant Thirty Second Volley	.88
Non-Dominant Thirty Second Volley	.89
One Minute Continuous Back Wall Volley	.85

With the exception of the non-dominant overhand return revealing an r of .43, the other seven items in the battery produced acceptable reliability correlations. The range was an r of .79 to an r of .90. The raw scores for the test-retest reliability are found in Appendix C.

Computer Program for Test Validation

Once the reliability of the eight test items was ascertained, it was necessary to select the appropriate

validation procedure. If the study was only concerned with the degree of correlation between one test and a criterion, the methodology would have merely required a simple product moment correlation. The test would be considered valid if it correlated highly with the test criterion. Since this study was based on the validation of a test battery consisting of eight test items, the statistical validation procedure was much more complex. The four steps in this method of evaluation were correlations with the criterion, intercorrelations, multiple correlations and regression equations.[7] The procedure determines how each test item correlates with the criterion, the necessary intercorrelation, matrix for multiple corrleation of all the test items with the criterion and the tests in the battery which can be eliminated. The Regression also determined the value of each test item in the battery. The BMD-02R Step Wise Regression Computer Program was selected for the analysis, since it was designed to reveal the results for all four steps. The remainder of this chapter will be concerned with the computed results for each of the four steps.

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[7] Ibid, p. 246-248.

Correlations with the Criterion

The first step for statistical validation of a test battery is to correlate each test item with the criterion. Appendix D contains the criterion scores from the partial round robin tournament. The extent of this measurement is the degree of validity and if this degree is expressed by a number it is the coefficient of validity. The test items which have high individual correlations with the criterion are considered good candidates for the ultimate test battery. However, a choice of the best items is not necessary at this initial stage. The results of the correlations are presented in Table III.

A review of the related literature indicated that the thirty second volley was a valid test in five studies. In this investigation, the test revealed a .796 correlation which was marginally second to the dominant overhand return with a reported .806. In descending order, the one minute continuous back wall volley was third with .778 followed by the non-dominant and dominant kill placement with correlations of .710 and .699 respectively. The dominant and non-dominant thirty second volleys were .620 and .611. The lowest correlation with the criterion was the non-dominant overhand return of .542.

TABLE III

INDIVIDUAL TEST ITEM CORRELATION WITH THE CRITERION

Test Item	Correlation
Dominant Overhand Return	.806
Non-Dominant Overhand Return	.542
Dominant Front Wall Kill Placement	.699
Non-Dominant Front Wall Kill Placment	.710
Thirty Second Alternate Hand Volley	.796
Dominant Thirty Second Volley	.620
Non-Dominant Thirty Second Volley	.611
One Minute Continuous Back Wall Volley	.778

Intercorrelation Matrix

In the second step, each test item was correlated with every other test item in the battery. It was a round robin of correlations so to speak. The main purpose of this step was to provide the necessary data for the multiple correlations along with the preceeding data of individual test item correlation with the criterion. The intercorrelations also helped to prevent duplication in that if one test item correlates highly with another test item and both correlate highly with the criterion, then one of the test

items can be eliminated. The rationale for elimination would be that both items are measuring the same thing and one could be omitted. The results of the intercorrelation are presented in Table IV. Notice that none of the intercorrelations were high enough to warrant elimination.

Multiple Correlation and Regression Equations

The last two steps in statistically analyzing the validity of a test battery are correlating all tests jointly with the criterion and weighing the relative importance of each test item in the battery. The steps are considered together, because the investigator computes the regression equation using the Wherry-Doolittle method of multiple correlation. The Wherry-Doolittle is a progressive procedure for manually calculating the regression coefficients in order to find the multiple correlation. For more than four independent variables, the investigator is encouraged to utilize a computer program such as the BMD-02R, since the process is tedious and highly subject to error. The computer program adds one independent variable at a time and provides the invesitgator with a comulative multiple R, multiple R^2 and increase in multiple R^2. In the final analysis, the computer eliminates

TABLE IV

INTERCORRELATION-MATRIX

Test Items	1	2	3	4	5	6	7	8
1. Dominant Overhand Return	1.000	.501	.660	.626	.608	.485	.504	.637
2. Non-Dominant Overhand Return		1.000	.404	.433	.455	.334	.305	.419
3. Dominant Front Wall Kill Placement			1.000	.461	.614	.482	.462	.543
4. Non-Dominant Front Wall Kill Placement				1.000	.619	.455	.508	.533
5. Thirty Second Alternate Hand Volley					1.000	.600	.612	.639
6. Dominant Thirty Second Volley						1.000	.522	.501
7. Non-Dominant Thirty Second Volley							1.000	.566
8. One Minute Continuous Back Wall Volley								1.000

the test items which have low weightings. It formulates a test battery of the remaining variables which can be used as the best predictor of the criterion. The results are presented in Table V.

TABLE V

BEST COMBINATION OF TEST ITEMS IN THE BATTERY

	VARIABLE (Test)	R	R^2	Increase in R^2	# (IVs) Included
1.	Dominant Overhand Return	.8064	.6665	.6665	1
8.	One Minute Continuous Back Wall Volley	.8823	.7785	.1120	2
5.	Thirty Second Alternate Hand Volley	.9060	.8208	.0423	3
4.	Non-Dominant Front Wall Kill Placement	.9160	.8391	.0184	4
3.	Dominant Front Wall Kill Placement	.9222	.8504	.0113	5

According to the computer readout, the dominant overhand return revealed the highest weighting of all the test items in the multiple correlation. The next variable to be added was the one minute continuous back wall volley. The

increase in R^2 of .1120 raised the multiple R to .8823. The third variable was the thirty second alternate hand volley. The multiple R^2 increase of .0423 raised the multiple correlation to .9060. The fourth variable added was the non-dominant front wall kill placement. The multiple R^2 increase of .0184 elevated the multiple R to .9160. The last variable to be added by the computer in the step wise regression was the dominant front wall kill placement. The multiple R^2 increase was .0113 which raised the multiple R to .9222. The test items which were eliminated from the battery by the computed step wise regression were the dominant thirty second volley, non-dominant thirty second volley and the non-dominant overhand return. The three tests combined only raised the multiple R from .9222 to .9272. Appendix E contains the raw data of the best items selected for the battery plus the residuals and the criterion computed for the residuals. It must be noted that the elimination was based on a fine line of discrimination and not because the test items were poor.

Once the five test items had been selected by the BMD-02R step wise regression, the test battery was ready for the final step. It was then necessary to balance the test battery based on the importance of each test. If the test items had revealed equal increases in the multiple R each time one of the five variables was added, the final step would have been superfluous. As is usually the case,

the contributions varied as illustrated in Table V. The procedure for establishing the weightings of each test item was the regression equations. Table VI contains the standard deviations, beta weightings and regression equation for each item.

TABLE VI

BETA WEIGHTINGS, STANDARD DEVIATIONS AND REGRESSION EQUATIONS FOR EACH TEST ITEM

Test Item		SD	Beta Weighting	Regression Equation
B_1	Dominant Overhand Return	2.32	.315	19.9
B_2	Dominant Front Wall Kill Placement	1.73	.179	15.2
B_3	Non-Dominant Front Wall Kill Placement	1.64	.202	18.12
B_4	Thirty Second Alternate Hand Volley	3.86	.163	7.01
B_5	One Minute Continuous Back Wall Volley	2.09	.283	19.87
RO	Criterion	147.15		

The beta weightings were computed by the Wherry-Doolittle Multiple Correlation. The computation for the regression equations is found in Appendix F. The findings revealed a regression constant of 19.9 for the dominant overhand return, 19.87 for the continuous back wall volley, 18.12 for the non-dominant front wall kill placement, 15.2 for the dominant front wall kill placement and 7.01 for the thirty second volley. The last regression constant was not low in comparison to the first four, because the range of sucessful attempts was 0 to 27 as compared to the first three test items which had a restricted range from 0 to 10.

After the regression equation constants were determined, the investigator established a multiplication table for each set of weightings.[8] In Table VII, the successful attempts for the range of possibilities on each test item in the battery have been converted to a value based on the regression equation constants. The potential test user of the five item battery merely needs to administer the test, convert the raw scores by using the multiplication table and add the values for a total test score. The results can be interpreted according to the examiner's discretion, ranked by the arbitrary scale devised by the investigator in Table VIII or the sigma scale in Table IX. However, the arbitrary and sigma scale can only be directly applied

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[8]Gladys Scott and Esther French, Measurement and Evaluation in Physical Education, (Iowa, 1959), p. 94.

to the subjects which were utilized in this study. The reader is cautioned that care must be utilized in using the scales with any other populations.

The procedure in the preceeding paragraph was repeated for a three item test battery. The regression equation constants were 24.3 for the dominant overhand return, 20.9 for the one minute continuous back wall volley and 9.5 for the thirty second alternate hand volley. The multiplication table for raw score conversion is presented in Table X. An arbitrary player classification is presented in Table XI. The sigma scale is presented in Table XII. Once again, the reader is cautioned that the arbitrary and sigma scales were based on the data in this study, and care must be utilized when using these scales with any other populations.

Based on the results of the computerized BMD-02R program, it would appear that there are five tests which can be used to classify a beginning handball player according to ability. The studies which have been reported in the related literature found the thirty second volley, service placement and power tests to be valid test items. Recently, one test author pointed to the importance of the front wall kill placement. The test items which have been selected for the test battery in this study contain the valid test items from previous attempts.

TABLE VII

CONVERSION OF SUCCESSFUL ATTEMPTS INTO VALUES BASED ON REGRESSION EQUATIONS CONSTANTS*

Successful Attempts	Item 1 (REC) 19.9	Item 2 (REC) 15.2	Item 3 (REC) 18.12	Item 4 (REC) 7.01	Item 5 (REC) 19.87
1	19.9	15.2	18.12	7.01	19.87
2	39.8	30.4	36.24	14.02	39.74
3	59.7	45.6	54.46	21.03	59.61
4	79.6	60.8	72.48	28.04	79.48
5	99.5	76.0	90.60	35.05	99.35
6	119.4	91.2	108.72	42.06	119.22
7	139.3	106.4	126.84	49.07	139.09
8	159.2	121.6	144.96	56.08	158.96
9	179.1	136.8	163.08	63.09	179.83
10	199.0	152.0	181.20	70.10	198.70
11				77.11	
12				84.12	
13				91.13	
14				98.14	
15				105.15	
16				112.16	
17				119.17	
18				126.18	
19				133.19	
20				140.20	
21				147.21	
22				154.22	
23				161.23	
24				168.23	
25				175.24	
26				182.25	
27				189.26	

*The above table is a five item test battery. Successful attempts beyond 10 pertain only to Items 4 and 5, since the first three items have a limit of 10 trials. The scale is based on the range established in the study. Values were determined by multiplying the successful attempts by the appropriate regression equation constants (REC).

TABLE VIII

ARBITRARY SCALE OF ABILITY CLASSIFICATIONS BASED ON POINTS EARNED

Ability Classification	Test Battery Score
Above Average	575.34 - 919.74
Average	449.34 - 575.33
Below Average	0 - 449.33

TABLE IX

SIGMA SCALE FOR 5 ITEM TEST BATTERY

100 - 919.74	65 - 625.74	30 - 331.74
95 - 877.74	60 - 583.74	25 - 289.74
90 - 835.74	55 - 541.74	20 - 247.74
85 - 793.74	50 - 499.74	15 - 205.74
80 - 751.74	45 - 457.74	10 - 163.74
75 - 709.74	40 - 415.74	5 - 121.74
70 - 667.74	35 - 373.74	0 - 79.74
$\bar{x}$ = 499.74	SD = 140	N = 120

TABLE X

CONVERSION OF SUCCESSFUL ATTEMPTS INTO VALUES BASED ON REGRESSION EQUATION CONSTANTS*

Successful Attempts	Item 1 (REC) 24.3	Item 2 (REC) 9.5	Item 3 (REC) 20.9
1	24.3	9.5	20.9
2	48.6	19	41.8
3	72.9	28.5	62.7
4	97.2	38	83.6
5	121.5	47.5	104.5
6	145.8	57	125.4
7	170.1	66.5	146.3
8	194.4	76	167.2
9	218.7	85.5	188.1
10	243	95	209
11		104.5	
12		114	
13		123.5	
14		133	
15		142.5	
16		152	
17		161.5	
18		171	
19		180.5	
20		190	
21		199.5	
22		209	
23		218.5	
24		228	
25		237.5	
26		249	
27		258.5	

* The above table is a 3 item test battery. Successful attempts beyond 10 pertain only to items 2 and 3, since the first test item had a limit of 10 trials. The scale is based on the range established in the study. Values were determined by multiplying the successful attempts by the appropriate regression equation constants (REC).

TABLE XI

ARBITRARY SCALE OF ABILITY CLASSIFICATION BASED ON POINTS EARNED*

Ability Classification	Test Battery Score
Above Average	396.87 - 769.96
Average	303.76 - 396.86
Below Average	0 - 303.75

* The above table is a 3 item test battery.

TABLE XII

SIGMA SCALE FOR 3 ITEM TEST BATTERY

100 - 766.46	65 - 496.96	30 - 227.46
95 - 727.96	60 - 458.46	25 - 188.96
90 - 689.46	55 - 419.96	20 - 150.46
85 - 650.96	50 - 381.46	15 - 111.96
80 - 612.46	45 - 342.96	10 - 73.46
75 - 573.96	40 - 304.46	5 - 34.96
70 - 535.46	35 - 265.96	0
$\bar{x}$ = 381.46	SD = 129.5	N = 120

CHAPTER V

SUMMARY AND CONCLUSIONS

Change has occurred rapidly in Physical Education during the past one hundred years primarily in the areas of instruction and evaluation. The profession has progressed from an "education of the physical" to an "education through the physical." The success of the new thinking of educating the whole child through activities has also expanded measurement beyond anthropometric evaluation and strength testing to cardiovascular research, general motor ability testing, attitude assessment and sports skill testing.

An area of particular interest is the sports skills tests. They were developed due to the need for evaluation of the teaching processs, as well as for the measurement of individual skill ability in the activity program of the new physical education curriculum. Numerous tests were constructed during the 1930's and 1940's. Unfortunately, the emphasis switched to physical fitness tests during World War II and thereafter and skill tests have been neglected. Consequently, many test batteries which are currently in use are twenty to thirty years old.

Authorities are particularly critical of the test batteries developed for the game of handball. Most of the studies are based on empirical judgement. Few were statistically analyzed and reliability and objectivity are rarely reported.

Handball is a relatively recent addition to the physical education curriculum. It has been excluded in the past due to a lack of facilities. Recent popularity is primarily due to an increase of facilities and its recognized carry over value and use as a physical conditioner. Handball facilities are being constructed on many Armed Service Bases, in Y.M.C.A.'s, Jewish Community Centers and colleges and universities across the nation. Many large companies are even providing courts for their employees. It is imperative that an evaluative instrument be developed to determine the ability levels of the participants who engage in the sport. A test for beginning players is particularly vital, since most test batteries have been developed for skilled players. The need for a valid instrument is further stimulated by the trend of many colleges who have already begun to offer advanced courses in the activity and other institutions who have adopted proficiency of minimal skill requirements. At present, colleges have difficulty in properly classifying students for an advanced course or for release from the activity.

Purpose

The purpose of this investigation was to develop a test battery which will classify a beginning handball player according to ability. More specifically, the intent was to determine if ability can be predicted by the proficiency in one or more of the eight test items in the battery of tests. The eight skill measures selected for the test battery were considered as those which are the most closely related to successful performance in the game.

Procedure

The subjects for this investigation were one hundred two male college students enrolled in P.E.M. 134 (Beginning Handball) at the University of Illinois, Chicago Circle during the Winter Quarter of 1973. The subjects were selected from six physical education classes. For the first four weeks, the subjects received basic instruction in handball skills. During weeks five through nine, the subjects competed in a partial round robin tournament with all the subjects in their respective classes. The last week of the quarter was allotted for the administration of the test battery. The scores of the test battery were correlated with the results of the partial round robin tournament.

Criterion

The criterion selected for the study was a partial round robin tournament. The players attempted to earn as many points as possible during a fifteen minute match with an opponent. The total number of points earned by a subject for all the matches played during the five week tournament were compared to the total number of points earned by the opponents in the matches played with the subject. If the subject's total point score was greater than the cumulative total of points earned by the subjects he competed against, a plus score resulted by subtracting the opponent's total from the subject's total. However, if the opponent's total score was higher than the subject's cumulative total, a minus score resulted by subtracting the subject's total from the opponent's total. The scores were adjusted to eliminate the minus values by using the lowest minus score in the tournament as one. The adjusted values represented the subject's criterion score.

Selection of the Test Items

Literature concerning the skills involved in the game of handball generally agree that there are five skills involved in the game. The skills are the service, front wall kill placement, back wall return, control volley and overhand, sidearm and underarm returns. Successful performance is prefaced on the assumption that the ball can be

hit with either hand. The items selected for the study were (1) dominant overhand return, (2) non-dominant overhand return, (3) dominant front wall kill placement, (4) non-dominant front wall kill placement, (5) thirty second alternate hand volley, (6) dominant hand thirty second volley, (7) non-dominant thirty second volley and (8) one minute continuous back wall volley.

Test Administration

During the tenth week of the course, the test battery was administered to the subjects. The test was administered twice, during consecutive class periods, by two different examiners to each subject to determine the reliability and objectivity of the test items. Five of the regulation courts located at the University of Illinois, Chicago Circle were used for the administration of the test items. The only preparation necessary in the five courts was the placing of black plastic electrical tape across the front wall twenty-four inches from the floor and six feet from the back wall on the floor.

Conclusions

The analysis of the data in this study was specifically related to test reliability, correlations of the test items with the criterion, intercorrelation of test items, multiple correlation and regression. The test reliability,

using test-retest technique, was analyzed by product-moment correlation in the computer. The four steps of statistical validation were computed by O.S.U. program BMD-02R. The program was a Bio-Medical Divison step wise regression. After the five test items were selected by the computer program, a Wherry-Doolittle Multiple correlation was computed to establish test item weightings and regression equations. The investigator followed the same procedure for the best three tests in the battery. The findings of the study are summarized as follows:

1. The test-retest correlations indicated that the dominant overhand return, dominant front wall kill placement, non-dominant front wall kill placement, thirty second alternate hand volley, dominant thirty second volley, non-dominant thirty second volley and one minute continuous back wall volley were reliable tests. The most reliable test was the thirty second alternate hand volley which revealed a .90 correlation. With the exception of the front wall kill placement, the other five tests ranged between .85 and .89. The .79 for the front wall kill placement was acceptable because it was a test measure of accuracy.
2. The individual test item correlation with the criterion revealed a .806 for the dominant

overhand return; .796 for the thirty second alternate hand volley, .778 for the one minute continuous back wall volley, .710 for the non-dominant front wall kill placement, .699 for the dominant front wall kill placement, .620 for the dominant thirty second volley, .611 for the non-dominant thirty second volley and .542 for the non-dominant overhand return.

3. The intercorrelation matrix did not indicate that any test items produced duplication of measurement.

4. The step wise regression selected five test items for the battery. The five items which produced the best multiple R of .922 were the dominant overhand return, the one minute continuous back wall volley, the thirty second alternate hand volley, the non-dominant and dominant front wall kill placement.

5. Three test items produced a multiple R of .90. The items were the dominant overhand return, the thirty second alternate volley and the one minute continuous back wall return.

Recommendations

The potential user of this test battery is afforded two options. Either the five item or the three item battery may be selected for administration. The results of the test battery can be converted into values based on regression constants and cumulatively added. Ability classifications can be obtained according to the examiners discretion, ranked by the arbitrary scale devised by the investigator or the sigma scale. The arbitrary scale and the sigma scale can only be directly applied to the subjects which were utilized in the study. The reader is cautioned that care must be utilized in using these scales with any other population. The investigator directs your attenion to the following recommendations:

1. There is a need for further validation studies with a larger number of subjects for the five item test battery, the three item test battery and a two item test battery.
2. Some of the test items can be considered for validation with intermediate and advanced handball players.
3. Norms need to be established on this test for beginning level handball players.
4. Test batteries are needed for one wall and three wall handball courts.

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APPENDIX A

Introductory Letter and Notes to the Instructor

Introductory Letter to the Handball Players Participating In The Study

This class, along with five others at the University of Illinois, Chicago Circle, has been selected to participate in a Doctoral Dissertation study. The research project is being conducted by Mr. Tom Sattler from Oklahoma State University in Stillwater, Oklahoma. Mr. Sattler is currently on leave of absence from this university.

The purpose of the study is to determine if the ability of a handball player can be predicted in a game based on the administration of a test battery of those skills which are inherent in the activity.

Since 1935, numerous attempts have been designed for a mutual purpose, but only three have been subjected to statistical analysis and only one study has been conducted in a regulation handball court. This particular study is considered unique, because the findings will be subjected to a rigorous statistical analysis based on step wise regression and all the guidelines of good test administration will be observed.

During the fourth week of this course, each member selected for this study will compete in a round robin tournament. All matches will be fifteen minutes in

duration. Only one continuous game will be played with an opponent during the fifteen minutes. The total number of points scored by each player will be recorded by the instructor. Your objective is to score as many points as possible during the fifteen minutes and attempt to keep your opponent from scoring against you. United States Handball Association rules will be observed for the game.

During the tenth week of the course, each player will be administered a test battery on two consecutive class days. The test will be given twice to determine the reliability of the test items.

It is vitally important that each player be in attendance each day for tournament play and testing. Good luck and thank you for your participation in this research project.

Instructor's Notes:

1. A tournament match will constitute fifteen minutes.
2. It has been suggested that all matches start and stop at the same time by the use of a whistle blast. (Be sure to collect the scores before allowing the players to leave the court.)
3. Some days have four scheduled matches, while others only have three. The latter will allow for make up matches.
4. After each number on the tournament sheet, there are two lines. The longer line is to be used for the player's name and the short line for the score the player earned in that particular match.
5. You have been supplied with two coppies of the schedule for each class. Suggestion - Post the duplicate copy each class period so the students can keep track of their next game.
6. Please print the player's name on the tournament schedule.
7. If there is a bye or a player is absent for a scheduled match, utilize the court for a make up. (Remember, our objective is to have a complete round robin tournament.)
8. It is extremely important that all players be available five minutes before class so the tournament can

begin on time. Your cooperation in advising your students as to the importance of this research project will be fully appreciated.

9. Thank you for all your cooperation.

APPENDIX B

Formula for Analysis of Variance

Analysis of Variance

$$\text{sst or } \Sigma x^2 \text{ tot.} - \Sigma x^2 \text{ tot.} - \frac{(\Sigma x \text{ tot.})^2}{n}$$

$$\text{ssb or } \Sigma x^2 \text{ b} = \frac{(\Sigma x_i)^2}{n_i} - (\Sigma x_t)^2$$

$$\Sigma x^2 w = (\Sigma x_1^2 - \frac{(\Sigma x_1)^2}{n_1}) + (\Sigma x_2^2 - \frac{(\Sigma x_2)^2}{n_2}) + (\Sigma x_3^2 - \frac{(\Sigma x_3)^2}{n_3})$$
$$+ (\Sigma x_4^2 - \frac{(\Sigma x_4)^2}{n_4}) + (\Sigma x_5^2 - \frac{(\Sigma x_5)^2}{n_5}) + (\Sigma x_6^2 - \frac{(\Sigma x_6)^2}{n_6})$$

$$\Sigma x^2 b + \Sigma x^2 w = \Sigma x^2 \text{ tot.}$$

$$\text{Variance Estimate} = \frac{\Sigma x^2}{df}$$

$$\text{msb} = \frac{\Sigma x^2 b}{df}$$

$$\text{msw} = \frac{\Sigma x^2 w}{df}$$

$$\text{F ratio} = \frac{\text{msb}}{\text{msw}}$$

APPENDIX C

Raw Data of Test-Retest

Subject	Dominant Overhand Return		Non-Dom. Overhand Return		Dominant Front Wall Kill Placement		Non. Dom. Front Wall Kill Placement		30 Sec. Alternate Hand Volley		30 Sec. Dominant Hand Volley		30 Sec. Non. Dom. Hand Volley		1 Min. Back Wall Volley	
	Test	Retest	Test	Retest	Test	Retest	Test	Retest	Test	Retest	Test	Retest	Test	Retest	Test	Retest
A 01	4	2	2	1	3	2	4	4	12	13	14	14	7	4	4	3
B 02	10	8	5	7	10	8	7	7	27	20	26	24	24	20	9	8
C 03	2	1	1	0	5	6	5	5	10	11	15	11	10	7	6	4
D 04	6	7	3	1	6	7	6	6	11	10	16	13	9	8	4	4
E 05	8	8	1	1	7	9	5	4	15	14	17	16	16	15	7	7
F 06	8	8	2	5	9	8	6	7	25	18	20	17	14	13	9	10
G 07	3	4	0	0	3	4	4	3	10	7	14	10	10	7	2	2
H 08	5	3	1	0	7	6	6	6	20	17	20	17	9	7	4	5
I 09	0	2	0	1	2	3	2	2	7	9	13	9	9	6	3	2
J 10	5	5	2	0	8	6	3	4	16	17	17	15	13	12	5	5
K 11	9	10	4	2	8	7	8	7	18	17	21	19	16	15	8	8
L 12	7	6	3	2	7	6	6	6	20	19	20	17	13	10	8	7
M 13	6	6	3	1	5	6	7	5	16	14	13	13	14	12	7	6
N 14	0	0	0	0	3	1	3	4	10	4	5	3	5	3	3	1
O 15	6	4	1	0	7	5	3	6	9	8	9	9	7	5	3	3
P 16	5	4	0	2	4	5	5	4	12	11	16	14	10	9	6	5
Q 17	6	4	0	2	8	6	4	6	12	12	11	12	14	9	6	4
A 18	4	4	3	1	4	4	5	4	14	14	11	12	11	8	7	5
B 19	5	4	2	1	7	6	4	6	12	9	13	14	10	8	6	5

C 20	5	3	2	0	8	6	3	3	14	14	12	11	14	10	5	4
D 21	5	4	0	1	6	5	6	5	14	13	13	14	13	11	5	5
E 22	6	5	3	1	9	7	6	6	20	18	13	12	10	9	4	4
F 23	5	5	2	0	6	5	4	4	16	17	18	14	14	10	4	5
G 24	6	4	2	1	5	5	4	3	12	11	16	12	8	7	3	3
H 25	3	0	0	0	0	0	3	4	3	3	9	6	8	5	0	1
I 26	2	2	1	0	3	2	4	3	9	9	13	11	10	10	6	4
J 27	6	7	2	0	6	6	5	4	15	15	20	17	12	9	4	4
K 28	4	4	3	1	5	4	4	5	12	11	18	14	10	9	4	4
L 29	7	7	0	2	5	6	8	7	15	15	17	13	21	18	8	7
M 30	6	6	4	2	5	5	4	5	11	11	14	13	10	9	8	6
N 31	5	5	3	1	5	4	3	3	16	15	15	14	12	9	6	6
O 32	4	4	3	1	6	7	5	4	13	12	16	16	8	7	5	4
P 33	7	7	4	2	8	9	7	7	27	21	21	22	25	20	8	8
Q 34	6	5	5	1	5	6	6	6	13	14	14	13	14	10	5	4
A 35	6	6	1	3	6	5	4	4	14	15	15	13	11	9	10	7
B 36	4	4	2	0	6	3	4	3	10	9	18	15	11	9	3	4
C 37	4	4	1	1	5	5	3	2	11	10	18	14	8	8	4	3
D 38	5	4	2	0	6	4	4	4	10	9	15	13	8	6	4	4
E 39	7	5	1	0	4	3	4	4	10	9	11	9	10	8	5	2
F 40	6	5	2	0	6	6	5	4	16	15	14	16	12	11	7	6

G	41	2	2	1	0	4	4	5	4	10	8	9	11	12	10	3	3
H	42	9	9	5	2	8	8	7	7	20	18	19	19	15	14	7	8
I	43	5	5	4	2	5	5	6	5	12	12	11	12	13	9	4	4
J	44	7	7	5	4	8	8	5	5	20	16	16	14	12	11	7	6
K	45	5	4	1	0	6	5	4	3	10	10	17	14	10	7	6	4
L	46	5	6	4	1	7	6	9	7	13	13	20	15	16	12	7	6
M	47	8	8	3	2	7	8	9	8	25	19	25	20	15	14	8	8
N	48	5	5	1	0	4	5	4	3	8	6	10	8	8	4	5	3
O	49	8	6	2	1	6	5	5	4	14	13	15	13	11	9	5	5
P	50	4	3	2	0	5	3	4	4	15	10	17	13	14	15	7	5
Q	51	4	5	0	2	6	5	5	5	12	13	14	14	15	11	4	3
A	52	8	8	5	2	7	8	7	6	15	14	15	14	13	12	7	8
B	53	8	6	0	2	8	7	3	3	16	16	18	18	11	10	4	5
C	54	0	1	0	0	4	4	5	5	9	10	13	10	10	6	5	3
D	55	7	9	3	1	5	4	5	5	19	20	17	15	12	10	5	7
E	56	10	9	4	3	7	8	7	6	20	19	16	15	11	12	6	7
F	57	3	3	2	0	5	3	4	4	10	9	13	9	10	8	3	3
G	58	7	7	2	2	7	8	8	7	22	17	16	16	12	13	7	8
H	59	5	4	3	1	5	5	7	5	11	12	13	13	12	8	4	5
I	60	0	0	0	0	3	4	3	2	10	5	12	10	10	6	1	2

J	61	7	4	0	1	6	7	4	3	14	14	13	14	12	12	8	6
K	62	9	8	2	1	7	10	7	6	25	18	24	22	20	17	10	9
L	63	6	6	3	1	6	5	5	5	20	16	15	13	13	12	6	6
M	64	6	4	1	0	5	4	5	4	13	13	10	11	8	11	3	3
N	65	6	6	3	1	8	7	5	4	13	13	14	14	13	10	4	5
O	66	5	3	2	0	6	5	4	3	12	10	16	15	7	6	2	3
P	67	8	7	3	1	6	6	5	5	19	18	16	15	14	10	6	7
Q	68	8	6	5	3	6	7	7	6	18	16	18	15	10	9	6	6
A	69	4	2	0	0	6	5	3	2	15	10	10	7	9	5	1	4
B	70	4	4	2	0	7	5	3	3	10	9	8	7	12	8	5	8
C	71	4	3	3	1	5	4	4	4	10	11	12	11	9	7	6	7
D	72	8	7	3	6	8	6	8	6	13	13	15	13	14	11	5	6
E	73	6	6	0	1	5	5	5	5	15	13	18	16	17	13	6	8
F	74	5	6	0	2	6	7	5	4	12	13	20	17	13	13	5	7
G	75	3	3	1	0	5	5	3	4	6	7	20	16	15	10	2	3
H	76	5	5	3	1	6	7	5	4	17	15	16	17	12	10	6	8
I	77	9	7	2	1	8	6	7	6	13	14	17	17	11	10	6	7
J	78	0	1	1	0	5	3	2	3	4	2	20	16	8	6	2	3
K	79	0	0	0	0	4	3	2	2	8	6	2	1	6	2	0	0
L	80	8	6	4	1	6	6	5	5	16	15	13	13	12	10	7	6

M 81	4	4	3	0	6	7	4	4	11	10	15	16	11	7	6	4
N 82	3	2	0	0	6	4	8	6	9	8	12	10	5	6	4	3
O 83	8	7	0	0	5	7	8	7	25	17	18	18	17	14	7	8
P 84	8	7	4	2	10	9	7	6	15	15	16	15	11	10	8	7
Q 85	9	8	4	1	8	9	8	7	23	21	20	17	11	9	9	8
A 86	3	2	0	0	6	4	5	4	12	14	2	10	16	12	3	2
B 87	3	2	1	0	4	2	2	1	8	10	9	6	7	5	3	2
C 88	8	7	3	4	9	8	6	7	20	16	20	25	13	11	10	8
D 89	8	6	3	2	7	6	6	5	20	16	14	13	14	9	7	6
E 90	4	3	3	1	4	3	4	3	9	10	10	15	10	5	4	2
F 91	4	5	2	1	7	5	3	4	13	12	14	18	9	8	5	4
G 92	4	4	2	1	5	6	4	3	10	8	9	12	7	6	6	4
H 93	10	8	3	1	8	8	6	7	14	13	14	15	15	11	8	6
I 94	7	6	5	2	8	8	7	6	18	16	15	14	18	14	7	7
J 95	4	4	2	0	9	6	4	3	12	12	12	15	13	9	6	4
K 96	6	7	4	1	4	4	5	4	20	16	12	13	13	10	6	5
L 97	7	6	2	0	1	6	5	5	16	14	12	13	13	10	7	6
M 98	4	4	2	0	6	5	3	2	12	12	9	14	10	9	4	3
N 99	7	5	0	1	6	5	6	4	15	13	13	13	9	8	5	5
O 100	5	6	2	1	5	5	6	6	20	17	15	15	12	10	6	5
P 101	4	5	3	2	6	5	5	5	14	13	13	16	10	7	6	5
Q 102	6	5	0	1	6	5	5	5	15	13	12	13	9	8	4	4

APPENDIX D

Results of the Partial Round Robin Tournament

ROUND ROBIN TOURNAMENT RESULTS CLASS 1

	A 1	B 2	C 3	D 4	E 5	F 6	G 7	H 8	I 9	J 10	K 12	L 12	M 13	N 14	O 15	P 16	Q 17	Subject	Opponent	Total	Adj.
A 1		6/36	30/10	22/20	16/35	14/37	25/20	18/25	22/11	13/23	16/33	15/35	10/28	33/15	26/15	18/32	15/26	299	401	-102	181
B 2	36/6		35/10	36/20	22/10	18/22	29/8	28/19	34/17	31/12	19/18	23/12	20/24	34/14	36//6	33/20	29/19	463	247	+216	499
C 3	10/30	10/35		19/20	7/24	10/32	20/15	18/25	31/13	24/28	7/31	7/28	12/30	20/25	30/16	20/27	13/20	258	399	-141	142
D 4	20/22	20/36	20/19		13/33	18/37	35/12	27/11	36/17	27/23	12/34	18/26	19/24	34/15	25/15	15/20	28/23	367	367	0	283
E 5	35/16	10/22	24/7	33/13		13/27	27/8	37/11	30/12	32/19	27/15	11/29	24/20	29/12	37/14	32/22	28/12	429	259	+170	453
F 6	37/14	22/18	32/10	37/18	27/13		35/15	30/11	30/18	29/10	17/16	39/19	38/7	39/16	34/10	30/3	43/23	519	221	+298	581
G 7	20/25	8/29	15/20	12/35	8/27	15/35		16/18	20/22	13/23	6/36	14/30	10/36	17/20	26/23	14/29	17/22	231	430	-199	84
H 8	25/18	19/28	25/18	11/27	11/37	11/30	18/16		25/11	18/14	8/27	12/31	18/26	30/4	29/10	15/15	25/19	300	331	-31	252
I 9	11/22	17/34	13/31	17/36	12/30	18/30	22/20	11/25		9/27	12/38	23/33	8/37	39/25	11/21	11/24	10/29	244	462	-218	65
J 10	23/13	12/31	28/24	23/27	19/32	10/29	23/13	14/18	27/9		10/31	9/23	15/15	35/12	20/10	16/23	25/15	409	325	+84	367
K 11	33/16	18/19	31/7	34/12	15/27	16/17	36/6	27/8	38/12	31/10		14/28	25/14	31/10	30/13	35/13	36/20	450	232	+218	501
L 12	35/15	12/23	28/7	26/18	29/11	19/39	30/14	31/12	33/23	23/9	28/14		35/20	35/10	31/9	28/22	31/16	454	262	+192	475
M 13	28/10	24/20	30/12	24/19	20/24	7/38	36/10	26/18	37/8	15/15	14/25	20/35		28/23	24/13	27/14	25/12	385	296	+89	372
N 14	15/33	14/34	25/20	15/34	12/29	16/39	20/17	4/30	25/39	12/15	10/31	10/35	23/28		12/31	22/31	14/21	249	467	-218	65
O 15	15/26	16/26	16/30	15/25	14/37	10/34	23/26	10/29	21/11	10/20	13/30	9/31	13/24	31/24		11/29	13/26	240	426	-186	97
P 16	32/18	20/33	27/20	20/15	22/32	3/30	29/14	15/15	24/11	23/16	13/35	22/28	14/17	31/32	29/11		16/20	340	337	+3	286
Q 17	26/15	19/29	20/13	23/28	12/28	23/43	22/17	19/25	29/10	25/25	20/36	16/31	12/15	21/14	26/13	20/16		323	358	-35	248

ROUND ROBIN TOURNAMENT RESULTS CLASS 2

	A 18	B 19	C 20	D 21	E 22	F 23	G 24	H 25	I 26	J 27	K 28	L 29	M 30	N 31	O 32	P 33	Q 34	Subject	Opponent	Total	Adj.
A 18		15/23	16/16	10/31	16/22	15/14	32/19	34/8	24/14	15/22	10/31	17/30	16/34	12/16	20/30	18/36	25/14	295	360	-65	218
B 19	23/15		15/17	10/17	22/11	30/15	33/17	36/13	33/8	27/17	30/9	10/21	14/17	25/27	21/18	11/37	12/15	352	274	+78	361
C 20	16/16	17/15		13/25	25/15	20/11	12/17	35/7	23/13	18/17	11/18	4/27	31/20	14/13	13/17	8/15	21/27	281	273	+8	291
D 21	31/10	17/10	25/13		15/25	18/18	22/11	31/4	14/17	12/30	12/11	15/27	16/15	18/15	18/18	10/31	18/22	292	277	+15	298
E 22	22/16	11/22	15/25	25/15		14/16	33/21	33/16	40/16	18/15	19/26	6/34	18/20	17/17	19/22	12/16	25/21	327	318	+9	292
F 23	14/15	15/30	11/20	18/18	16/14		20/15	23/6	30/17	11/22	13/11	14/23	13/13	16/13	18/24	15/39	11/31	258	311	-53	230
G 24	19/32	17/33	17/12	11/22	21/33	15/20		35/4	23/14	10/29	11/21	8/23	21/19	14/29	14/25	13/22	11/22	260	360	-100	183
H 25	8/34	13/36	7/35	4/31	16/33	6/23	4/35		23/31	20/28	15/39	15/35	2/30	16/32	17/30	25/35	18/23	227	510	-283	1
I 26	14/24	8/33	13/23	17/14	16/40	17/30	14/23	31/23		6/29	9/31	17/23	12/20	9/18	6/26	12/39	29/35	230	431	-201	82
J 27	22/15	17/27	17/18	30/12	15/18	22/11	29/10	28/20	29/6		21/27	14/17	13/10	23/19	12/18	16/39	17/21	325	288	+37	320
K 28	31/10	9/30	18/11	11/12	26/19	11/13	21/11	39/15	31/9	27/21		5/23	15/24	13/23	19/23	5/35	20/22	301	301	0	283
L 29	30/17	21/10	27/4	27/15	34/6	23/14	23/8	35/15	23/17	17/14	23/5		23/19	18/9	23/9	8/29	15/18	370	209	+161	444
M 30	34/16	17/14	20/13	15/16	20/18	13/13	19/21	30/20	20/12	10/13	24/15	19/23		17/19	17/21	9/29	12/32	296	295	+1	284
N 31	16/12	27/25	13/14	15/18	17/17	13/16	29/14	32/16	18/9	19/23	23/13	9/18	19/17		24/14	14/35	14/21	302	282	+20	303
O 32	30/20	18/21	17/13	18/18	22/19	24/18	25/14	30/17	26/6	18/12	23/19	9/23	21/17	14/24		15/35	6/23	316	300	+16	299
P 33	36/18	37/11	15/8	31/16	16/12	39/15	22/13	35/25	39/12	39/16	35/5	8/29	29/9	35/14	35/15		27/18	478	230	+248	531
Q 34	14/25	15/12	27/21	18/22	21/25	31/11	22/11	23/18	35/29	21/17	22/20	18/15	32/12	21/14	23/6	18/27		361	285	+76	359

ROUND ROBIN TOURNAMENT RESULTS CLASS 3

	A 35	B 36	C 37	D 38	E 39	F 40	G 41	H 42	I 43	J 44	K 45	L 46	M 47	N 48	O 49	P 50	Q 51	Subject	Opponent	Total	Adj.
A 35		11/14	21/12	17/5	29/5	22/21	31/12	28/6	18/21	16/23	22/12	15/28	14/17	15/19	20/16	15/17	14/16	312	248	+64	347
B 36	14/11		19/26	15/18	22/14	12/24	35/4	21/34	15/12	20/21	22/4	14/17	4/27	17/18	17/20	17/15	17/17	281	282	-1	281
C 37	12/21	26/19		17/18	31/11	11/30	31/9	7/32	11/21	5/34	20/20	12/24	8/35	20/16	18/29	24/22	18/30	271	371	-100	183
D 38	5/17	18/15	18/17		23/34	11/20	13/23	7/34	11/17	17/19	21/18	10/28	30/28	25/14	17/14	29/8	19/22	264	328	-64	217
E 39	5/29	14/22	11/31	34/23		9/34	13/26	16/18	10/32	18/24	20/37	13/39	10/30	12/18	15/24	11/15	12/36	223	438	-215	68
F 40	21/22	24/12	30/11	20/11	34/9		35/8	8/17	11/17	15/17	17/23	20/14	11/27	33/4	12/21	18/12	28/19	337	244	+93	376
G 41	12/13	4/35	9/31	23/13	26/13	6/35		6/36	16/25	7/31	19/29	8/27	14/35	19/14	13/30	41/12	8/35	235	414	-179	104
H 42	6/28	34/21	32/7	34/7	36/12	17/18	36/6		33/9	20/10	25/11	23/17	22/12	33/17	22/12	38/16	33/19	453	220	+233	516
I 43	21/18	12/15	21/11	17/11	18/16	17/11	25/18	9/33		4/28	22/15	8/31	3/38	19/6	15/21	11/31	13/12	240	297	-57	226
J 44	23/16	21/20	34/5	19/17	32/10	17/15	31/7	10/20	28/4		34/8	18/11	19/11	24/11	22/24	30/11	22/14	384	194	+190	473
K 45	12/22	4/22	20/20	18/21	24/18	23/17	29/19	11/25	15/22	8/34		9/24	6/36	18/15	15/23	24/25	13/21	250	363	-113	160
L 46	28/15	17/14	24/12	28/10	37/20	14/20	27/8	17/23	31/8	11/18	24/9		9/20	18/17	16/11	29/4	21/12	351	221	+130	413
M 47	20/18	27/4	35/8	28/20	39/13	27/11	35/14	12/22	38/8	11/19	36/6	20/9		30/9	21/19	29/15	24/7	432	202	+230	513
N 48	17/14	18/17	16/20	14/25	30/10	4/33	14/19	17/33	6/19	11/24	15/18	17/18	9/30		9/19	13/15	9/19	219	333	-114	161
O 49	19/15	20/17	29/18	14/17	18/12	21/12	30/13	10/31	21/15	14/22	23/15	11/16	19/21	19/9		22/9	15/23	305	265	+40	323
P 50	16/20	15/17	22/24	8/29	24/15	12/18	12/41	16/38	13/11	11/30	24/25	4/29	15/29	15/13	9/22		22/26	238	387	-149	134
Q 51	17/15	17/17	30/18	22/19	15/11	19/28	8/35	19/33	12/13	14/32	21/13	12/21	7/24	19/9	23/15	26/22		281	315	-34	249

ROUND ROBIN TOURNAMENT RESULTS CLASS 4

	A 52	B 53	C 54	D 55	E 56	F 57	G 58	H 59	I 60	J 61	K 62	L 63	M 64	N 65	O 66	P 67	Q 68	Subject	Opponent	Total	Adj.
A 52		25/5	25/14	27/4	17/11	20/9	16/16	20/10	23/10	18/18	7/21	35/7	32/17	25/14	29/5	11/9	16/25	346	195	+151	434
B 53	5/25		35/9	12/23	16/24	11/21	8/30	16/16	22/15	15/18	4/26	16/21	29/16	34/8	29/9	11/22	8/27	271	310	-39	244
C 54	14/25	9/35		14/25	3/18	16/16	13/39	21/19	16/15	11/32	10/31	6/30	15/26	12/26	22/21	6/33	9/28	197	419	-222	61
D 55	4/27	23/12	25/14		15/21	19/12	11/15	21/12	29/10	30/16	10/35	15/12	42/8	29/9	20/12	13/27	21/30	327	260	+67	350
E 56	11/17	24/16	18/3	21/15		36/5	11/26	37/9	30/14	29/19	12/12	26/15	18/9	20/9	19/19	36/9	15/18	373	215	+158	436
F 57	9/20	21/11	16/16	12/19	5/36		15/30	18/20	27/16	10/39	9/40	10/38	16/16	20/23	20/20	6/36	6/20	220	400	-180	103
G 58	16/16	30/8	39/13	15/11	26/11	30/15		24/14	21/11	25/6	7/24	16/19	29/5	26/12	34/5	14/15	16/16	368	201	+167	450
H 59	10/20	16/16	19/21	12/21	9/37	20/18	14/24		26/7	10/14	4/42	22/21	12/12	24/12	15/18	12/18	12/21	237	322	-87	196
I 60	10/23	15/22	15/16	10/29	14/30	16/27	11/21	7/26		14/14	1/32	5/30	15/36	5/25	15/25	8/24	5/30	166	410	-244	39
J 61	18/18	18/15	32/11	16/30	19/29	39/10	6/25	14/10	14/14		6/38	26/12	19/3	12/19	35/12	26/18	16/20	316	282	+34	317
K 62	21/7	26/4	31/10	12/12	40/9	24/7	42/4	32/1	38/6	35/10		34/12	28/4	31/11	31/14	27/9	16/17	468	137	+331	614
L 63	7/35	21/16	30/6	12/15	15/26	38/10	19/16	21/22	30/5	12/26	12/34		21/12	13/25	45/9	19/18	17/14	332	289	+43	326
M 64	17/32	16/29	26/15	8/42	9/18	16/16	5/29	12/12	36/15	3/19	4/28	12/21		16/25	32/18	6/29	16/18	234	366	-132	151
N 65	14/25	8/34	26/12	9/29	9/36	23/20	12/26	12/24	25/5	17/12	11/31	25/13	25/16		14/15	13/14	23/24	266	336	-70	213
O 66	5/29	9/29	21/22	12/20	9/20	20/20	5/34	18/15	25/15	12/35	14/31	9/45	18/32	15/14		10/30	16/30	218	421	-203	80
P 67	9/11	22/11	33/6	27/13	19/19	36/6	15/14	18/12	24/8	18/26	9/27	18/19	29/6	14/13	30/10		16/18	337	219	+118	394
Q 68	25/16	27/8	28/9	30/21	18/15	20/6	16/16	21/12	30/5	20/16	17/16	14/17	18/16	24/23	30/16	18/16		356	228	+128	411

ROUND ROBIN TOURNAMENT RESULTS CLASS 5

	A 69	B 70	C 71	D 72	E 73	F 74	G 75	H 76	I 77	J 78	K 79	L 80	M 81	N 82	O 83	P 84	Q 85	Subject	Opponent	Total	Adj.
A 69		6/35	8/31	11/31	18/30	15/28	25/25	12/30	19/31	12/32	28/8	10/23	12/32	14/28	10/29	15/30	12/29	227	452	-225	58
B 70	35/6		14/26	16/31	12/30	15/22	18/19	9/31	19/28	25/22	27/8	8/27	22/20	25/29	12/30	13/35	9/33	279	397	-118	165
C 71	31/8	26/14		11/31	11/29	16/26	24/14	14/19	8/21	32/17	27/14	8/15	16/22	26/16	10/30	9/4	4/36	259	316	-57	226
D 72	31/11	31/16	31/11		25/22	25/10	29/8	17/21	8/21	27/9	36/10	17/18	27/8	24/7	13/20	18/16	9/26	365	237	+128	411
E 73	30/18	30/12	29/11	22/25		22/21	31/9	21/18	11/27	35/14	30/19	9/28	17/17	34/9	8/31	8/26	18/36	355	321	+34	317
F 74	28/15	22/15	26/16	10/25	21/22		33/13	21/18	9/18	27/13	34/14	11/23	31/18	20/15	15/18	12/28	8/25	328	296	+32	315
G 75	25/25	19/18	14/24	8/29	9/31	13/33		16/21	10/31	29/26	21/12	8/29	15/29	20/24	8/31	16/30	17/32	248	425	-177	106
H 76	30/12	31/9	19/14	21/17	18/21	18/21	21/16		11/18	30/10	29/11	15/17	23/21	28/16	13/23	13/29	8/31	328	286	+42	325
I 77	31/19	28/19	21/8	21/8	27/11	18/9	31/10	18/11		30/5	29/6	7/19	36/14	36/8	16/15	13/23	10/27	372	212	+160	441
J 78	32/12	22/25	17/32	9/27	14/35	13/27	26/29	10/30	5/30		27/13	6/28	17/32	17/28	6/39	18/30	16/33	255	450	-195	88
K 79	8/28	8/27	14/27	10/36	19/30	14/34	12/21	11/29	6/29	13/7		12/35	14/30	5/31	16/32	16/28	15/30	193	454	-261	22
L 80	23/10	27/8	15/8	18/17	28/9	23/11	29/8	17/15	19/17	28/6	35/12		35/5	29/10	15/22	6/29	8/22	355	209	+146	429
M 81	32/12	20/22	22/16	8/27	17/17	18/31	29/15	21/23	14/36	32/17	30/14	5/35		15/23	8/31	15/35	8/37	294	391	-97	186
N 82	28/14	29/25	16/26	7/24	9/34	15/20	24/20	16/28	8/36	28/17	31/5	10/29	23/15		13/36	11/34	7/38	275	401	-126	157
O 83	29/10	30/12	30/10	20/13	31/8	18/15	31/8	23/13	15/16	39/6	32/16	22/15	31/8	36/13		16/22	16/32	419	217	+202	485
P 84	30/15	35/13	4/9	16/18	26/8	28/12	30/16	29/13	23/13	30/18	28/16	29/6	35/15	34/11	22/16		17/22	416	221	+195	478
Q 85	29/12	33/9	36/4	29/6	36/18	25/8	32/17	31/8	27/10	33/16	30/15	22/8	37/8	38/7	32/16	22/17		492	179	+313	596

ROUND ROBIN TOURNAMENT RESULTS CLASS 6

	A 86	B 87	C 88	D 89	E 90	F 91	G 92	H 93	I 94	J 95	K 96	L 97	M 98	N 99	O 100	P 101	Q 102	Subject	Opponent	Total	Adj.
A 86		28/21	16/35	14/33	28/26	18/21	14/21	10/35	5/34	3/35	25/14	10/18	7/33	23/12	15/25	10/30	10/17	236	410	-174	106
B 87	21/28		17/35	12/26	23/16	14/34	14/36	5/34	11/30	13/13	19/23	12/36	26/14	18/24	14/28	16/24	17/18	252	419	-167	116
C 88	35/16	35/17		25/15	35/13	24/10	34/15	13/27	22/8	32/13	36/4	18/18	36/7	20/18	26/29	25/24	24/20	440	254	+186	469
D 89	33/14	26/12	15/25		26/12	25/15	33/8	30/18	11/22	16/16	24/12	20/13	34/8	18/22	24/30	25/22	24/26	384	275	+109	392
E 90	26/28	16/23	13/35	12/26		14/14	16/33	10/34	7/33	6/33	11/16	10/22	18/30	11/18	20/14	15/16	20/17	225	392	-167	116
F 91	21/28	34/14	10/24	15/25	14/14		19/3	9/26	15/21	22/9	22/14	9/20	35/10	14/16	16/16	18/14	19/13	292	267	+25	308
G 92	21/14	26/14	15/34	8/33	33/16	3/19		7/34	25/30	31/13	30/10	10/22	22/14	14/20	14/22	16/12	16/15	301	322	-21	262
H 93	35/10	34/5	27/13	18/30	34/10	26/9	34/7		15/14	32/9	33/11	15/13	32/12	16/17	18/18	20/24	21/25	410	227	+183	466
I 94	34/5	30/11	8/22	22/11	33/7	21/15	30/25	14/15		30/10	33/16	28/16	35/13	16/22	24/25	18/13	19/16	395	242	+153	436
J 95	35/3	13/13	13/32	16/16	33/6	9/32	13/31	9/32	10/30		13/17	5/33	30/13	16/12	18/30	31/14	30/22	294	294	0	283
K 96	14/25	23/19	4/36	12/24	16/11	14/22	10/30	11/33	16/33	17/13		9/24	11/21	21/18	29/13	14/17	16/16	237	355	-118	165
L 97	18/10	36/12	18/18	13/20	22/10	20/9	22/10	13/15	16/28	33/5	24/9		29/3	20/19	18/22	18/18	16/16	336	225	+111	394
M 98	33/7	14/26	7/36	8/34	30/18	10/35	14/22	12/32	13/35	13/30	21/11	3/29		18/22	18/26	16/12	10/17	227	392	-165	118
N 99	12/23	24/18	18/20	22/18	18/11	16/14	20/14	17/16	22/16	12/16	18/21	19/20	22/18		14/21	21/19	21/14	296	265	+31	314
O 100	25/15	28/14	29/26	30/24	14/20	16/16	22/14	18/18	20/24	30/18	13/29	22/18	26/18	21/14		16/10	21/9	356	287	+69	352
P 101	30/10	24/16	24/25	16/15	14/18	12/16	24/20	13/18	14/31	17/14	18/18	12/16	19/21	10/16	22/25		21/11	290	290	0	283
Q 102	17/10	18/17	20/24	26/24	17/20	13/19	15/16	25/21	16/19	22/30	16/16	17/16	17/10	14/21	9/21	11/21		273	305	-32	251

APPENDIX E

Best Combination of Test Items With Criterion Plus Residuals

SUBJECT	Criterion	Composite	Residual	Dominant Overhand Return	1 Min. Back Wall Volley	30 Sec. Volley	Non. Dom. Front Wall Placement	Dominant Front Wall Placement
A 01	181	165.1658	15.8342	4	4	12	4	3
B 02	499	625.9880	-126.9880	10	9	27	7	10
C 03	142	197.0107	-55.0107	2	6	10	5	5
D 04	283	269.4165	13.5835	6	4	11	6	6
E 05	453	369.3008	83.6992	8	7	15	5	7
F 06	581	510.1799	70.8201	8	9	25	6	9
G 07	84	90.7351	-6.7351	3	2	10	4	3
H 08	252	311.2188	-59.2188	5	4	20	6	7
I 09	65	1.7794	63.2206	0	3	7	2	2
J 10	367	274.7444	92.2556	5	5	16	3	8
K 11	501	508.6704	-7.6704	9	8	18	8	8
L 12	475	434.0986	40.9014	7	8	20	6	7
M 13	372	348.6248	23.3752	6	7	16	7	5
N 14	65	12.0644	52.9356	0	3	10	3	3
O 15	97	167.3772	-70.3772	6	3	9	3	7
P 16	286	240.5325	45.4675	5	6	12	5	4
Q 17	248	270.6196	-22.6196	6	6	12	4	8
A 18	218	256.7588	-38.7588	4	7	14	5	4
B 19	361	261.0093	99.9907	5	6	12	4	7
C 20	291	247.8779	43.1221	5	5	14	3	8
D 21	298	260.5605	37.4395	5	5	14	6	6
E 22	292	338.3369	-46.3369	6	4	20	6	9

F 23	230	253.3184	-23.3184	5	4	16	4	6
G 24	183	207.5120	-24.5120	6	3	12	4	5
H 25	1	-49.2046	50.2046	3	0	3	3	0
I 26	82	118.1126	-66.1123	2	6	9	4	3
J 27	320	284.4504	35.5496	6	4	15	5	6
K 28	283	209.7908	73.2092	4	4	12	4	5
L 29	444	392.5964	51.4064	7	8	15	8	5
M 30	284	304.0508	-20.0508	6	8	11	4	5
N 31	303	259.6006	43.3994	5	6	16	3	5
O 32	299	251.1040	47.8960	4	5	13	5	6
P 33	531	514.7554	16.2446	7	8	27	7	8
Q 34	359	297.4006	61.5994	6	5	13	6	5
A 35	347	352.3794	-5.3794	6	10	14	4	6
B 36	281	185.9211	95.0789	4	3	10	4	6
C 37	183	175.0750	7.9250	4	4	11	3	5
D 38	217	207.7759	9.2241	5	4	10	4	6
E 39	68	217.2703	-149.2703	7	5	10	4	4
F 40	376	325.0044	50.9956	6	7	16	5	6
G 41	104	110.2957	-6.2957	2	3	10	5	4
H 42	516	483.9287	32.0713	9	7	20	7	8
I 43	226	239.5934	-13.9534	5	4	12	6	5
J 44	473	409.6904	63.3096	7	7	20	5	8
K 45	160	247.2717	-87.2717	5	6	10	4	6

L 46	413	401.8516	11.1484	5	7	13	9	7
M 47	513	539.2256	-26.2256	8	8	25	9	7
N 48	161	170.5283	-9.5283	5	5	8	4	4
O 49	323	311.5251	11.4749	8	5	14	5	6
P 50	434	416.2996	17.7004	8	7	15	7	7
Q 51	249	205.8125	43.1875	4	4	12	5	6
A 52	134	274.4087	-104.4087	4	7	15	4	5
B 53	244	292.1375	-48.1375	8	4	16	3	8
C 54	61	117.0962	-56.0962	0	5	9	5	4
D 55	350	324.5828	25.4172	7	15	19	5	5
E 56	436	449.9509	-13.9509	10	6	20	7	7
F 57	403	141.0298	-98.0298	3	3	10	4	5
G 58	450	434.1863	15.8137	7	7	22	8	7
H 59	196	249.4897	-53.4897	5	4	11	7	5
I 60	39	2.6492	36.3508	0	1	10	3	3
J 61	317	317.7876	-0.7876	7	8	14	4	6
K 62	614	556.3440	57.6560	9	10	25	7	7
L 63	326	337.3958	-11.3958	6	6	20	5	6
M 64	151	200.0996	-49.0996	6	3	13	5	5
N 65	213	282.5181	-69.5181	6	4	13	5	8
O 66	80	183.1121	-103.1121	5	2	12	4	6
P 67	394	368.1021	25.8979	8	6	19	5	6
Q 68	411	410.0632	0.9368	8	6	18	7	6

A 69	58	172.6724	-114.6724	4	4	5	3	6
B 70	165	241.7209	-76.7209	4	8	10	3	7
C 71	226	234.3091	-8.3091	4	7	10	4	5
D 72	411	400.8416	10.1584	8	6	13	8	8
E 73	317	332.3516	-15.3516	6	8	15	5	5
F 74	315	297.3818	17.6182	5	7	12	5	6
G 75	106	127.2756	-21.2756	3	3	6	3	5
H 76	325	346.6511	-21.6511	5	8	17	5	6
I 77	441	418.5803	22.4197	9	7	13	7	8
J 78	88	69.8711	18.1289	0	3	8	2	5
K 79	22	-88.6370	110.6370	0	0	4	2	4
L 80	429	366.2151	62.7849	8	7	16	5	6
M 81	186	243.5020	-57.5020	4	6	11	4	6
N 82	157	205.1833	-48.1833	3	4	9	8	6
O 83	485	473.7778	71.2222	8	7	25	8	8
P 84	478	463.2830	14.7170	8	8	15	7	10
Q 85	596	545.6816	50.3184	9	9	23	8	8
A 86	106	165.0198	-59.0198	3	3	12	5	6
B 87	116	56.7253	59.2747	3	3	8	2	4
C 88	469	526.7480	-57.7480	8	10	20	6	9
D 89	392	407.4355	-15.4355	8	7	20	6	7
E 90	116	173.1233	-57.1233	4	4	9	4	4
F 91	308	233.2292	74.7708	4	15	13	3	7

G 92	262	207.4421	54.5579	4	6	10	4	5
H 93	466	445.8762	20.1238	10	8	14	6	8
I 94	436	427.0076	8.9924	7	7	18	7	8
J 95	283	276.3127	6.6873	4	6	12	4	9
K 96	165	315.1392	-150.1392	6	6	20	5	4
L 97	394	348.9778	45.0222	7	7	16	5	7
M 98	118	185.2244	-67.2244	4	4	12	3	6
N 99	314	294.2034	19.7966	7	4	15	6	6
O 100	352	318.3472	33.6528	5	6	20	6	5
P 101	251	244.6509	6.3491	6	4	15	5	6
Q 102	283	276.4968	6.5032	4	6	14	5	6

APPENDIX F

Computation of the Wherry-Doolittle Multiple R, Beta Weightings and Regression Equation

Multiple R

$$R = \checkmark(B_1RO_1) + (B_2RO_2) + (B_3RO_3) + (B_4RO_4) + (B_5RO_5)$$

Beta Weightings

$$B_5 = x24$$

$$B_4 = (B_5 \times e17) + x16$$

$$B_3 = (B_5 \times e11) + (B_4 \times d11) + x11$$

$$B_2 = (B_5 \times e5\ ) + (B_4 \times d5\ ) + (B_3 \times c5) + x5$$

$$B_1 = (B_5 \times e2\ ) + (B_4 \times d2\ ) + (B_3 \times c2) + (B_2 \times b2) + x2$$

Regression Equation

$$RE = B_1(\frac{SD_0}{SD_1}) + B_2(\frac{SD_0}{SD_2}) + B_3(\frac{SD_0}{SD_3}) + B_4(\frac{SD_0}{SD_4}) + B_5(\frac{SD_0}{SD_5})$$

VITA

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Candidate for the Degree of

Doctor of Education

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